# RESEARCH AND DEVELOPMENT FOR NATIONAL DEFENSE

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Benjamin Thomas Wayne Sutherlin

Submitted to the

Faculty of the School of International Service

of The American University

in Partial Fulfillment of

the Requirements for the Degree

of

MASTER OF ARTS

AN ABSTRACT

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## ABSTRACT

It was the purpose of this paper to examine the necessity for the association of research and development with the national defense requirement; to determine the methods and procedures utilized by the Atomic Energy Commission, the National Aeronautics and Space Administration, and, particularly, the Department of Defense to achieve this association; and, finally, to evaluate the effectiveness of the research and development funds expended to support the established defense policies.

Today, as never before, national defense focuses on the technical question, and it has been postulated that technological surprise may represent the primary danger to national security. This emphasis on the technological dimension of decision-making requires that research and development be utilized to erect a national military posture to meet the long-term needs of security.

The author has analyzed this scientific-military phenomenon in its relationship to the defense policy of the United States.

TABLE OF CONTENTS

CHAPTER | PAGE

## LIST OF TABLES



## LIST OF CHARTS

# CHAPTER I

## THE PROBLEM AND DEFINITIONS OF TERMS USED

Today, the United States is faced with two major realities: (1) the increasing role of science and technology in defense policy decisions, and (2) the increasing Federal support for research and development. These two aspects are often contrasted as the "role of science in government" and the "role of government in science." While they are closely related, it is important to recognize that they often pose quite different problems and, in fact, are often confused. To present what is perhaps the clearest example of the interaction of these two forces, this thesis will examine how the knowledge of nature and technique is organized to affect the possibilities for decision-making in the field of national defense. It is in this area that the technical performance of weapons systems has direct bearing on the ability to carry out national policies and on the choices which are considered tenable.

### I. THE PROBLEM

#### Statement of the Problem

It becomes clear from the almost daily recital of issues before the President and before the Congress that research and development for national defense is a major

element in the most excruciating decisions that must be made. The United States is engaged in a technological war which has no current prospect of ending. This fact sets the goal of substantial technological superiority--a superiority which provides the flexibility to react quickly to changing conditions in a highly unpredictable world. Since the "closed society" nature of certain nations makes it difficult to assess accurately their technological capabilities, an attempt must be made to stay well ahead of all possible enemies far into the future.

During the past two decades, there has been a growing awareness of the relationships between threat, strategy, and national security on the one hand, and research and development on the other. Not only is there more intimate involvement of technology in many vital national decisions today than in times past, but there is also an accelerating tempo of activity, an increasing complexity of issues involved, an increasing number of alternatives, and a growing seriousness in the consequences of error. From determinations at the national level on key elements of strategy come the decisions which shape research and development in terms of required weapons systems and supporting technology. Research and development must respond to meet successfully its principal objective--that of providing superior weapons systems required for national survival.

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During the past two decades, there has been a growing awareness of the relationships between threat, strategy, and national security on the one hand, and research and development on the other. Not only is there more intimate involvement of technology in many vital national decisions today than in times past, but there is also an accelerating tempo of activity, an increasing complexity of issues involved, an increasing number of alternatives, and a growing seriousness in the consequences of error. From determinations at the national level on key elements of strategy come the decisions which shape research and development in terms of required weapons systems and supporting technology. Research and development must respond to meet successfully its principal objective—that of providing superior weapons systems required for national survival.

It is expected that over fifteen billion dollars have been expended on research and development by various activities of the Government during fiscal year 1965. This expenditure, although representing but 15 per cent of the total Federal budget, is, in effect, well over one-third of that portion of the budget which is susceptible to control, since a great part of the budget is committed to fixed requirements, such as debt retirement, interest, veterans' benefits, subsidies and prior-year commitments for capital expenditures. If funding is any indication, the amount spent for research and development emphasizes the priority that has been placed on meeting national defense needs. It was the purpose of this study to examine the necessity for the association of science with the defense requirement, to determine the methods and procedures utilized by the Federal Government to achieve this association, and to evaluate the effectiveness of the research and development expenditures to support the established defense policies.

## Value of the Study

The Government's organization for research and development has not evolved according to any master plan. Support has traditionally been scattered throughout the Government, with research and development primarily a means to the ends of each agency. World War II brought a striking

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expansion in Federal support of technological programs and funds for this effort, while already in the billions, is annually being increased. The Department of Defense, which is demonstrating a remarkable faith in science, supports a vast research and development program, and the National Aeronautics and Space Administration and the Atomic Energy Commission have been created, each with heavy responsibilities in the field. An overwhelming preponderance of the Federal research and development budget is allocated to the above three agencies whose programs are intimately related to national defense. The responsibility for the planning, organization, and management for research and development is assigned to these Federal agencies in line with their prescribed missions. If the Federal Government contributes to these missions with such determination as is indicated by the percentage of the Federal budget allocated, it is reasonable to question to what extent these funds contribute to national defense. The most relevant considerations and judgments must be focused on major national choices, including the area of defense. How much can be afforded and where among several competing end-uses shall the limited resources of this country be placed? These are the kinds of choices that a loosely-knit system of public and private decision-making have traditionally accomplished with considerable versatility and wisdom. But an advancing technology and an

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uncertain world call for an extraordinary effort to encompass technical considerations with which the majority of people are largely unfamiliar.

## II. DEFINITIONS OF TERMS USED

### Research and Development

"Research and development" is a composite term which covers an enormous variety of activities in the natural and social sciences ranging from the most abstract mathematical inquiry on the one hand to the most practical designing, testing, and evaluating of a new device on the other. If the primary objective is to make further improvements on the product or process, then the work comes within the definition of research and development. All too often, these activities have been collectively called "science" when, in fact, they represent a diversity of functions and interests as wide as the Federal Government itself. Therefore, the activities connected with research and development are broken down into two sets of categories in this study. One set defines the activities in the traditional scientific terms and the second set expands these terms as interpreted by the Department of Defense. An attempt has been made in this paper to limit the discussion of all facets of research and development to the physical sciences, which include the physical sciences proper, and the mathematical and

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engineering sciences. These three categories of physical science are defined as follows: (1) physical sciences proper are concerned primarily with the understanding of the natural phenomena associated with non-living things; (2) mathematical science employs logical reasoning with the aid of symbols and is concerned with the development of methods of operations utilizing such symbols; and (3) engineering science, which is concerned with studies directed toward making specific scientific principles usable in engineering practice. Such sciences as life, psychological, and social, which are considered as being only indirectly associated with defense in such tangible dimensions, are intentionally not included in this study.

## National Defense

The ideals of the United States have historically tended toward a certain kind of world order, an order based on the rule of law, on free and independent nations dealing with one another to their mutual benefit and peacefully settling their disputes with one another. Fundamentally, the Nation's objectives might be summed up as follows: globally, a more stable world, and domestically, a nation where government and machine serve humanity. But the first responsibility is to the security and welfare of the citizens of the United States.

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The uninterrupted crises in world affairs since the end of World War II have led to a minor revolution in politics, particularly international relations and foreign policy, in the United States. The increased tempo of international change, at first, led to an emphasis on the attempt to use information provided by the social sciences in the formulation of responses to the rapid succession of international crises confronting the United States. This essentially-pragmatic approach, firmly rooted in traditional American values proved suggestive, but could not adequately explain a world in which fundamental change had become commonplace. It did, however, lead to a new awareness that a painstaking search for theoretical first principles must be undertaken.

Typical of this search has been the increased attention paid to a vaguely-defined area called national security, usually located somewhere in the academic discipline of international relations. Two situations, both encouraging specialization, were realized. These situations were the growing complexity of international affairs, and the increasingly self-conscious involvement of the United States as the leader of a world system. An army of specialists in the Government, in independent research institutions, and at universities, began working in such basic areas as the choice of military strategies and appropriate weapons systems; the allocation of economic resources to competing defense and

non-defense needs; the role of scientists in national policy-making; the political setting for strategic decision-making; the problem of alliances and coalitions; the technical, economic, and political challenges of disarmament; the institutions and techniques for international cooperation; and the creation of a world community. This search for objective criteria inevitably led the experts to analyze the theoretical foundations of a national security policy.

National security policy, then, came to be basically defined as the complete range of integrated decisions and courses of actions taken to secure national objectives. But security and national objectives are equally as elusive in definition. Security covers a range of goals so wide that highly-divergent policies can be interpreted as policies of security. If security becomes a matter of a value judgment, the Nation is secure when it feels secure and the amount of defense needed to maintain this security is simply "enough." The policies adopted by a government chosen by the people obviously should be designed to serve their objectives and these become the national objectives. Defined in terms relating solely to Federal research and development, such objectives include the generally-accepted propositions of increasing the gross national product of the country and personal wealth of individuals, improving the standards of living of all citizens, sustaining peace throughout the

non-defense needs; the role of scientists in national policy-making; the political setting for strategic decision-making; the problem of alliances and coalitions; the technical, economic, and political challenges of disarmament; the institutions and techniques for international cooperation; and the creation of a world community. This search for objective criteria inevitably led the experts to analyze the theoretical foundations of a national security policy.

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world, maintaining a strong defensive posture, upholding a high level of employment, and conserving certain natural resources. These are the criteria examined by the legislative committees charged with authorizing appropriations to support a defense research and development policy.

If the concept that national security is the ability of a nation to protect its internal values from external threats is accepted, national security policy may be roughly subdivided into two categories. The first category would be that of foreign policy, which is concerned mainly with relations with other states; and the second category would be that of defense policy, which is the decisions and courses of action taken to organize and bring to bear military power to secure national aims. These areas overlap and are interdependent in complex ways and any policy-level official who is concerned with one area must also be concerned with the other. Sometimes a third subdivision of national security policy is identified; that is, domestic policy. This area pertains to internal action taken in support of external national objectives. Domestic policy is not treated separately here because it is an interest common to practially all agencies of the national government.

The problem of research and development as examined in this paper is centered on the second category, that of national defense. The attempt to achieve the indispensable

national objectives through national defense involves moral questions and human values--political, social, economic, and psychological questions as well as technological ones. But today, as never before, national defense focuses on the technical question, and it has been suggested that technological surprise presents the primary danger to security. This new emphasis on the technological dimension of decision-making requires an orientation to the manifold practical task of erecting a national military posture to meet the long-term needs of security. In this dimension, decisions are concerned with lead time, or the period between the conception of a program and its completion or implementation, and military functions and capabilities. The technological planner conceptualizes in terms of components of national power plotted against future time, and the concrete decisions made are predicated on the initiation of programs, procurement, and the training of the forces required.

There are those who maintain that national security has decreased even though military power has increased and see no solution in the technological dimension. But it must be remembered that the technological decisions of today are the basis on which the strategic environment of tomorrow will be based, by setting the limits of future United States positive action as well as performing the negative function of averting military destruction.

## III. ORGANIZATION OF REMAINDER OF THE THESIS

In the foreword to the Study submitted to the Committee on Government Operations, titled Science Organization and the President's Office, Senator Henry M. Jackson pointed out that the tide of political power flows with the tide of scientific and technical power. He maintained that, whereas a decade ago the United States scientific and technical leadership was taken for granted, today it is being effectively challenged.

The determination of the broad direction and scale of the Government's part in the national scientific effort is the duty of the President. He establishes the priorities and makes the decisions that enlist science and technology in support of foreign policy and defense goals. He is ultimately responsible for the wise employment of that portion of the national budget which is spent annually for research and development. Since the Bureau of the Budget coordinates the whole Federal budget, the most effective means of control of research and development is at that level. Science advisers may give lofty advice and complex recommendations but, in the end, the words must be converted into deeds and the funds requested by a government agency to accomplish this rests with the approval or disapproval of intended projects or programs.

The Jackson Subcommittee felt that when parochial scientific counsel is measured against the perspective of the President's office it, like economic and military advice, must be subject to civilian control. The President, in shaping and guiding the Government's science and technological effort, is critically dependent upon able leadership and staffing within the executive departments and agencies. No one person in government, nor any one committee of directors, can have detailed knowledge across the whole spectrum of science. This truism can just as well be applied to research and development for national defense.

Science and technology within the national defense structure can be traced back almost to the beginning of the Republic. The first chapter of this paper attempts to trace the effect that science has had on defense and vice versa. It was found that the link between the scientist and the soldier had to be maintained to promote national security, but this led to the search for the most satisfactory methods of achieving such a relationship. Prior to World War II, the Federally-sponsored scientific activities were largely confined to government-owned installations. The war altered this pattern. In addition to enlarging its own performance capacity, the Government found it necessary to seek talent and resources wherever they existed or could be assembled. Industrial companies supplied much of the effort, and

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contributions of great value to the war effort were made by the staffs of colleges and universities, hospitals, private research laboratories, other non-profit institutions and research centers. The trends established during the war have continued, but in more pronounced terms.

Eight government departments and agencies now support the major national technological effort, and almost all the other parts of the Government use science in varying degrees to help meet their agency objectives. During 1964, or earlier, virtually every major department and agency having scientific programs elevated research and development to the policy level, appointing an Assistant Secretary or a Director specifically for this activity. This emphasis reflects the very nature of science itself. The President and his assistants are charged with ordering and focusing scattered programs in the right direction. If optimum use is to be made of the available scientific and engineering manpower resources, programs must be carefully planned and these resources concentrated where they will make the greatest contributions to the defense posture. But, since there is no Supreme Court of Science, except the testing ground of nature itself, the President cannot afford to rely on any one source of scientific advice. Chapters II through V present the methods employed by this multi-scientific advisory staff and concentrate on the Federal research and

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development effort as it applies to the national defense program. The concern for security and the potential of modern technology cause most of the research and development funds to be dedicated to this area. A definition of the programs pursued and a description of the various methods of achieving technological results are discussed.

It becomes obvious that, in deciding on defense research and development programs, the President will generally find his choice facilitated by the existence of multiple and independent sources of scientific advice. This is a condition that prevails in the case of many of the departments and agencies whose actions have significant foreign policy consequences, especially in the use of scientists by the Department of Defense, the National Aeronautics and Space Administration, and the Atomic Energy Commission. These three agencies are not only more directly connected to the national defense field, but, perhaps because this is so, absorb the great majority of Federal research and development expenditures. Their programs, as they pertain to the defense effort, are, therefore, discussed individually.

The last six chapters focus on the one department most significant to the national defense effort, the Department of Defense. This department has developed an extensive and intricate organization for the conduct of research and development. A detailed analysis of that organization

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should be of more than academic interest since the greatest share of responsibility for national defense through research and development is centered here. Each of the Military Services is subject to the guidance and control of the Director of Defense Research and Engineering and, therefore, attention is centered on that part of the Department of Defense. The question of adequacy for the broad category of the defense program, research and development, is by its very nature difficult to answer with certainty. The ability to perceive future requirements is limited, and many of the undertakings in this area must be viewed as insurance premiums--hedges against possible future developments that may never occur. But where contingencies exist and can be identified, they must be provided for. Therefore, the methods of providing the scientific and technical information required by the policy-makers to pursue effectively a national defense program are explored. The majority of this paper has been constructed from Congressional hearings and reports; and through these dialogues, a presentation of the Federal research and development program, as related to national defense, is unfolded.

CHAPTER II

SCIENCE AND NATIONAL DEFENSE

Science has, within the last few decades, stimulated in an amazing manner the efforts of man to control his environment and adapt it to his use. The laboratories make possible repeated experiments and provides the researcher with an opportunity to observe phenomena, time and time again, under identical conditions. The use of mathematics as a tool of investigation has added to the competence of the scientist in this increasingly-complex world. The ability of scientists and engineers to apply laboratory principles to specific problems has given a great impetus to the advance of technology. Among nations, therefore, the race for national preeminence in industrial and military technology has become, to no small extent, one between scientists. But, up to the time of the launching of a Soviet satellite in October, 1957, the United States had been exceedingly careless regarding the scientific aspects of international competition.[1] It was determined, at that time, that, if the rate of scientific rivalry were not increased, the United States would be doomed to a position

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[1]The Industrial College of the Armed Forces, "The Economics of National Security," Research and Development, Vol. VIII (Washington: Government Printing Office), p. 11.

of inferiority in science, which would later lead to a decline to second place in technology, political influence, and military strength. American interest in scientific and engineering education and research and development had been tremendously stimulated by one manifestation of Russian progress. The value of science to national defense, which had been made clear in World War II, was now strikingly reemphasized.

## I. THE EFFECT OF TECHNOLOGY ON NATIONAL DEFENSE

### Expansion of Federal Support

During the middle of the twentieth century, scientific method began to play a rapidly-increasing part in the advance of technology with many industrial corporations creating their own departments of research and development. But industrial technology was not the only sector to make great use of research and development. The scientific activities fostered by the Federal Government, mainly for the purpose of national defense, also provided for radical changes in military technology. Research and development activities, on which the continued effectiveness of all the defense forces depends, became one of the major programs by which the Defense Department provided the military diversity

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and flexibility required for the security of the nation.[2] Aside from national defense, science and technology are also of increasing significance to other Federal programs. Therefore, it is perhaps not startling that today fifteen cents of every American tax dollar is spent by the Federal Government for research and development and, through its programs, the Government supports two-thirds of the entire national effort. What is striking is the leap in levels of Government-supported research and development from the pre-World War II years to the present. In 1940, the Government spent only seventy-four million dollars for research and development. By 1953, this figure had risen to about two billion dollars and, for fiscal 1965, expenditures are expected to exceed fifteen billion dollars.[3]

## Criteria for Established Priorities

The Federal research and development programs reflect largely the national defense and foreign policy objectives

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[2]United States Bureau of the Budget, *The Budget in Brief: Fiscal Year 1965* (Washington: Government Printing Office, 1964), p. 26.

[3]Perhaps the most significant thing that can be said about these figures is that, isolated, they are misleading. At best, they may be educated estimates and generalizations. To make an accurate comparison between today's level of support and that of former years, for example, one must consider not only the changes in dollar values but also the change in the Federal agency's definitions. These definitions now include, as research and development, many items and projects which, in former times, may have been found and funded in other administrative categories.

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established since World War II, and the investments are concentrated in three areas that absorb approximately 90 per cent of the Federal research and development budget. These three areas are the military, space, and atomic energy--by magnitude in the order named.[4] Major resource allocations must be and are made by the Government; and these allocations cannot deal with program details, but they indicate the overall importance of each activity to the defense of the United States. Research and development programs are no exception, and their overall level must be decided as a combination of three basic factors: (1) the need, (2) the technological progress, and (3) the available resources. The national posture has come to depend less on production capacity in being and more on the race for shorter lead times in the development and deployment of new weapon systems and of countermeasures against similar systems in the hands of potential enemies. Modern technology has endowed arms competition with a self-sustaining quality. Many new steps have to be taken, less for any clearly-conceived political or even strategic purpose than for fear of missing an important point that one's adversary may exploit in the accelerating process of research and development. The

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[4]"Research: By 1970, a $20 Billion Plateau?," Business Week, No. 1826 (July 25, 1964), 65.

national goal, as expressed by President Johnson in his fiscal year 1966 Budget message, is to maintain a strong research and development program to insure that United States forces are always the most modern in the world.

## II. THE EVOLUTION OF THE SCIENTIFIC-MILITARY RELATIONSHIP

### Historical Trends

The cooperation of scientists and the Armed Forces is not a new relationship. As a result of the interest of a number of American scientists and Government officials, the National Academy of Sciences was established in 1863, for the purpose of providing scientific advice to the United States Government. The use made of this Academy by the War Department between 1863-1913 bespeaks a bygone era. During those years, the Department requested the Academy to constitute scientific committees on exactly five matters to further that agency's mission:

A. Tests for the purity of whiskey,
B. Preservation of paint on Army knapsacks,
C. Galvanic action from the association of zinc and iron,
D. Exploration of the Yellowstone, and
E. Meteorological science and its application.[5]

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[5]United States Congress, Senate, Committee on Government Operations, Science and Technology Act of 1958, Staff Study (Washington: Government Printing Office, 1958), p. 115.

national goal, as expressed by President Johnson in his fiscal year 1966 budget message, is to maintain a strong research and development program to insure that United States forces are always the most modern in the world.

## II. THE EVOLUTION OF THE SCIENTIFIC-MILITARY RELATIONSHIP

Historical Trends

The cooperation of scientists and the Armed Forces is not a new relationship. As a result of the interest of a number of American scientists and Government officials, the National Academy of Sciences was established in 1863, for the purpose of providing scientific advice to the United States Government. The use made of this Academy by the War Department between 1863-1913 outlines a bygone era. During those years, the Department requested the Academy to constitute scientific committees on exactly five matters to further that agency's mission:

A. Tests for the purity of whiskey,
B. Preservation of paint on Army knapsacks,
C. Galvanic action from the association of zinc and iron,
D. Exploration of the Yellowstone, and
E. Meteorological science and its application.[5]

[5] United States Congress, Senate, Committee on Government Operations, Science and Technology Act of 1958, Staff Study (Washington: Government Printing Office, 1958), p. 113.

It would be unfair to presume from this list that the War Department was uninterested in new weapons systems; but, until the turn of the century, military technology, like industrial technology, generally developed independently of advances in basic scientific skill.

What transformed the relationship between science and war was the fact that, in the twentieth century, the development of technology became increasingly dependent upon advances in basic knowledge about the physical world. As a technically-advanced nation, both the rate of technological innovation and the growth of new scientific knowledge began increasing exponentially. Crudely measured by the volume of scientific publications, scientific knowledge has been doubling every ten to fifteen years.[6]

Conflicting Philosophies

A number of scientists have advanced the proposition that the military tends to be more interested in improving existing weapons than in developing radically new ones, and they argue that a separate civilian agency be established to undertake new development. Both scientists and military have explained the difference in their approach to military

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[6] Ellis A. Johnson, "The Crisis in Science and Technology and its Effect on Military Development," Operations Research, VI (January-February, 1958), 14-15.

research and development, "quantum jumps versus improvements," with the hypothesis that the soldier's interest in developing entirely new weapons must always be inhibited by his concern for the possibility that war may come in the near future and, in this event, his interests are best served by improving existing weapons. A current example of this controversy, and where the scientists gained their objective of at least a new name for a weapons system and the military gained their objective of improving an existing system, is the POSEIDON submarine-launched ballistic missile. In order to emphasize the improved capabilities of the existing POLARIS missile which was achieved by increasing the payload weight and volume, as well as accuracy, the combination of change was to be called the POSEIDON system.

An explantion less flattering to the military for this difference of philosophy is the occasional assertion by scientists that theirs is a profession which stimulates original and creative thoughts, while that of the military tends to develop minds which accept the existing situation without too much question. This is a judgment the scientists may extend to the diplomat and the politician as well. Scientists have been demanding and searching for quantum jumps ever since the end of World War II,[7] and this search

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[7] Warner R. Schilling, "Scientists, Foreign Policy and Politics," American Political Science Review, LVI (June, 1962), 103.

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[7]Warner R. Schilling, "Scientists, Foreign Policy and Politics," American Political Science Review, LVI (June, 1962), 293.

is certainly not excluded from the defense aspect of national objectives. While scientific advisers are considered professional experts in their special fields, they also often have strong opinions about the morality or political utility of development in the laboratory. Since scientists are, after all, human, beliefs could be allowed to color technical judgments with special causes receiving priority. It would appear then that, while, in the main, the technologist contributes to the defense policy of this nation, as much sales resistance is needed in this area as in any other.

# CHAPTER III

## FEDERAL RESEARCH AND DEVELOPMENT: TRADITIONAL CONCEPT

The term "research and development," as used in the Federal budget, means the conduct of activities intended to obtain new knowledge or to apply existing knowledge to new uses. The Department of Defense uses the term "research, development, test and evaluation," which is a somewhat fuller but more cumbersome term for the same concept. For more clarity, the term should actually be separated into "research" and "development." It is confusing, in many instances, to talk about them in the same way because they are often approached differently. A development program, with its heavy cost schedule and its goal of a single device or the system as a whole, is usually a different problem than a research tool of exploring and gaining knowledge.

### I. RESEARCH VERSUS DEVELOPMENT

#### Research

The Federal Government finances research not only to accomplish agency missions--usually a forerunner to development--but also to increase the broad body of scientific and technical knowledge which underlies the future advancement of the Nation's welfare, economic growth and security. This

is not only true of basic research conducted primarily in academic institutions, but also in government, industrial, and other laboratories focusing on fundamental problems.

While research is a relatively small portion of the total effort, the potential productive payoff is immense. In contrast to development, research is more diffuse in its objectives, less structural in its organization, necessarily freed from a definite time schedule, and susceptible to advance planning only as new knowledge is developed.[1]

Development

Development, on the other hand, is supported to design, fabricate, test, and evaluate prototypes of materials, devices, systems or processes needed to accomplish specific agency missions. These include prototypes of complex devices, such as military weapons, space vehicles, nuclear weapons, and "systems" for such programs as air defense or air traffic control.

Because development is pointed toward well-developed objectives the total level of support and the balance between the alternatives can be better decided on the basis of some assessment of what each project can contribute to national goals. Here it should be possible to set

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[1]Jerome B. Wiesner, Where Science and Politics Meet (New York: McGraw-Hill, 1965), p. 71.

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priorities. Development planning is comparatively straightforward and quantifiable, and the conduct of programs is subject to normal management principles with control over cost and quality. Choices in research are often more complex.[2]

Federal funds for development are double those for research and nearly four-fifths of all the development funds are spent through contracts with industry. The balance is spent chiefly in Federally-operated centers, particularly those of the Department of Defense, the National Aeronautics and Space Administration, and the Atomic Energy Commission.[3]

## II. ACTIVITIES

Research and development is also a phrase that describes a number of different kinds of activities. In the traditional concept, these activities are subdivided into five major headings:

1. Fundamental research;
2. Supporting research or exploratory development;
3. Feasibility studies, operations analysis, and technical advice;
4. Development and engineering of products, processes or systems; and
5. Test and evaluation activities.

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[2] *Ibid.*, p. 70.

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Fundamental Research

Basic research is scientific inquiry undertaken to obtain knowledge and an understanding of natural laws, and to gain a comprehension of relationships among phenomena not previously understood. This type of research does not aim at the creation of practical mechanisms; its goal is that of understanding. Basic research obviously does not always produce tangible, immediately usable, or spectacular results. The tendency, then, may be to cut funds for basic research when "research and development funds look too high." Such policies are considered generally ill-conceived for the following reasons:

1. Basic research is generally relatively inexpensive;
2. The lack of basic knowledge can increase the cost of later stage research more than cutting the basic project might save;
3. The cutbacks affect primarily the capacities of universities to train qualified scientific and technical manpower; and
4. The long-term goals are never achieved adequately.

It should be pointed out that fundamental research holds the key to any radical change to be made in technology. Unless the curiosity of American students for uncovering the relationships of natural phenomena is encouraged and developed, the future of this country in a world of competitive power politics is by no means secure.[4]

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[4]The cost of all such work to the leading sponsors of basic research runs less than 6 per cent of total government

Supporting Research

The general principles uncovered by basic research are of practical value as the foundation for specific projects to create new devices or processes. The beginning of a specific project takes place when, in some fertile and imaginative mind, an idea for practical change assumes form. An inspiration for a new device or technique may come from any of a variety of people, including scientists, independent inventors, executives, workers at the various levels of production, salesmen, or consumers of the product to be improved. Or, it may arise from an organized attack on a problem by a group of investigators who, when the need has been recognized, have been set to work to originate a plan to bring about the required improvements.

Advancements in military technology are spurred by competition between rival states involving the deadly serious matter of national survival. Ideas in this field may arise in the research staffs of Army, Navy, or Air Force laboratories, or from college, industrial, or institutional contractors working on military research. This exploratory research, which means investigation in a certain field to

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research and development expenditures. United States Congress, House of Representatives, Select Committee on Government Research, National Goals and Policies, Study Number X (Washington: Government Printing Office, 1964), p. 25.

discover possibilities for technical improvement, has proven to be one of the most likely sources of ideas for change.

## Feasibility Studies

Sometimes termed applied research, this type of research is concerned with the practical application of knowledge or understanding gained (often defined as all research except basic research). In the earlier phases of the creation of a new device or process, there often remains much applied research to be accomplished. This consists of study, investigation, and experimentation to determine the best methods by which a specific device or process may be developed.

## Development and Engineering

Development is the systematic use of scientific knowledge directed toward the production of useful materials, devices, systems or methods, including design and development of prototypes and processes. A model is often built up from a small breadboard layout intended to demonstrate a principle, or a full-scale prototype which incorporates the characteristics agreed upon. Before the development stage is ended, the prototype must operate to the satisfaction of the agency or department which expects to produce it or supervise its production, or in the case of the Defense Department, it must be approved by a board representing the using agency.

After the prototype has been accepted, a limited number may be produced so that they may be tested under service conditions. After development and testing, the accepted prototype or process and the test data are gone over by the production engineers, in some cases design engineers, for redesigning to fit the system of mass production.

## Test and Evaluation

During the various steps in research and development, there must be continuous and careful evaluation of the idea which is to be put in practical form. Basic research must be scrutinized to ascertain what new practical applications are possible. When the specific idea is created, it must be tested by applied research to find out its merit. Continuous emphasis on evaluation at every important step can reduce the probability of serious errors and add to the efficiency of research and development.

# CHAPTER IV

## FEDERAL RESEARCH AND DEVELOPMENT: FACILITIES AND MANPOWER

Facilities which are considered as conducting research and development consist of those organizations with the primary aim of either developing new knowledge or applying existing knowledge to new uses. These activities may be carried out in government installations or in the facilities of private, State, or local organizations using Federal funds. Generally excluded from these categories are organizations which expend funds for experimental production, information activities, and training programs. The analysis also omits expenditures for research performed independently by contractors within overhead arrangements on some procurement contracts funded in Defense Department procurement accounts. Expenditures for the collection of general-purpose statistics by the Census Bureau and other agencies are also excluded.

Expenditures for "research and development facilities" also include amounts for physical facilities, such as land, buildings, and major equipment, regardless of whether the facility is to be used or owned by the Federal Government or by a private, State, or local organization.

## I. FACILITIES AND MISSIONS

Since there are several thousand public and private enterprises engaged in research and development for defense, and in the light of the widely-varied requirements, and the importance of the results sought, it is of interest to consider briefly the types of agencies now available and the missions they are expected to perform.[1] An analysis of their respective characteristics and functions will be presented, as well as the relative amount of the total Federal research and development budget they consume. Arranged in order of decreasing proximity to and control by the Government, they can be described as:

1. In-house government laboratories and organizations, such as the Naval Research Laboratory;
2. Government-owned, contractor-operated organizations which are privately staffed and managed for the Government, such as the Oak Ridge Atomic Energy Laboratories;
3. University associated research centers, such as the Applied Physics Laboratory (Johns Hopkins University);
4. Non-profit private foundations, such as the RAND Corporation;
5. Colleges and universities, such as the Massachusetts Institute of Technology; and
6. Private, profit-making organizations, such as Westinghouse.

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[1]The Department of Defense alone has contracts with over three hundred universities and not-for-profit institutions. United States Congress, Senate, Committee on Government Operations, Report to the President on Government Contracting for Research and Development (Washington: Government Printing Office, 1962), p. 28.

The feature which these organizations have in common, and which permits them to be of service, is the presence of personnel of unusual qualifications, and sometimes, the availability of unique facilities useful for research and development or related operations.

Although there may not be entire agreement as to the detailed functions of any of the agencies listed above, consensus is normally achieved in regard to their outstanding characteristics which are presented below.

## The In-House Governmental Laboratory

These organizations are parts of major departments or agencies of the Government and, as such, are staffed by personnel employed by the Government and subject to governmental regulations and requirements. They enjoy a close and continuing relationship to the agency they serve, which permits maximum responsiveness to the needs of that agency and a maximum sense of sharing the mission. Such operations accordingly have a natural advantage in conducting research, feasibility studies, developmental and analytical work, user tests, and evaluations which directly support the management functions of the agency. These facilities absorb 25 per cent of the Federal research and development budget.

## Government-Owned, Contractor-Operated Organizations

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securing competent scientific and technical personnel to perform research and development work where very complex and costly facilities are required and government control is desired. These government, but not wholly in-house, organizations have usually been created to serve new departments or major entities of the Government which, at the time, do not have established in-house related facilities. In practice, this type of organization has been created to provide a means of rapidly mobilizing talent and facilities to concentrate on relatively narrow objectives, usually in fields new to both the Government and to the civilian economy. These facilities, together with private profit-making organizations, utilize 60 per cent of the total Federal budget for research and development.

University Associated Research Centers

These organizations consist of a laboratory or division which has been separately organized by, but remains legally a part of, a university to handle certain major government research and development efforts. They are usually well suited to basic or applied research because the facilities are so large and expensive that the research acquires the character of a major program best carried out in an entity apart from the regular academic organization. Research in such centers often benefits from the active participation of university scientists, while, at the same

time, the sponsoring university (and sometimes other co-operating universities) benefits from increased opportunities for research by its faculties and graduate students. All research and development conducted by universities involves 11 per cent of the total budget.

Non-Profit, Private Foundations

These organizations are non-profit in that there are no shareholders or investors in the company. They usually receive all allowable cost-plus fees ("development" or "general support" allowances). This fee is designed to provide for operational stability and flexibility and independent, self-initiated research. These factors are important for maintaining the cohesiveness and quality of the organization. If strongly led, these foundations can provide a degree of independence, both from government and from the commercial market, which may make them particularly useful as a source of objective analytical advice and technical services. They have, on occasion, provided an important means for establishing a competent research organization for a particular task more rapidly than could have been possible within the less flexible administrative requirements of the Government.

At the same time, this type of organization has

occasioned the greatest controversy.[2] They have frequently been asked to perform the role of judge or evaluator of the concepts and components of other organizations. To do this, it is essential, if they are to play the role impartially, that they avoid conflicts of interest and that they themselves be free from adherence, or appearance of preference, for particular military services, systems, components or concepts, including those of their own origination. It is also necessary that these foundations recognize their own responsibilities and proper spheres of operations, and the resulting limitation on their freedom of action. They are needed as idea-creating or conceptual entities, and as evaluators of the concepts of others. However, they are not themselves charged with responsibility for the defense of the nation or operation of its defensive systems. It is the Government, through the Military Services, or otherwise, which must actually defend the nation and, consequently, must have the responsible and final role in the specification of the needed systems, components, and related materials. Similarily, it is the Government which must undertake actual procurement, test, installation, and evaluation, and,

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[2] United States Congress, House of Representatives, Subcommittee of the Committee on Government Operations, Systems Development and Management, Part 1, Hearings (Washington: Government Printing Office, 1962), p. 366.

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[2] United States Congress, House of Representatives, Subcommittee of the Committee on Government Operations, _Systems Development and Management, Part 1_, Hearings (Washington: Government Printing Office, 1962), p. 368.

subsequently, the operation of the defensive systems, and the like. These organizations must recognize that their future lies in functions such as "thinkers," planners, or managers, rather than producers of hardware. The non-profit foundations absorb approximately 4 per cent of the total budget.

Colleges and Universities

This unique intellectual environment has proven to be highly conducive to successful undirected and creative research by highly-skilled specialists.[3] Such research is not amenable to management control by adherence to firm schedules, well-defined objectives, or predetermined methods of work. In the college and universities, graduate education and basic research constitutes an effective means of introducing future research workers to their fields in direct association with experienced people in those fields, and in an atmosphere of active research work. Applied research appropriate to the universities is that which broadly advances the state-of-the-art.

Private, Profit-Making Organizations

Because of the wide ranging scope of the private,

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[3]United States Congress, Senate, Committee on Government Operations, Report to the President on Government Contracting for Research and Development, op. cit., p. 11.

profit-motivated enterprises, and the consequent diversity of their staffs, facilities, and fields of technology, the scope of functions which can be effectively performed by these organizations is extremely wide. Under the spur of competition, and since they are able to afford the cream of the scientist crop, not only do these organizations receive the largest share of Federal funds for research and development, but, consequently, account for the majority of new developments in science and technology.

## II. MANPOWER

Today, in the United States, about one-half million people are working as scientists, nearly one million as engineers, one million as technicians, and one-quarter million as teachers of science and mathematics in secondary schools. These numbers refer to persons "working as" scientists, engineers, technicians, or teachers. In the statistics of manpower, persons "trained as" are defined quite differently and are counted by numbers of academic degrees awarded in relevant fields. Some persons holding such degrees are not working in science and technology--and some persons working in the field do not hold such degrees. For purposes of this paper, scientists and engineers are persons engaged in scientific or engineering work requiring knowledge and training equivalent at least to that acquired in a four-year college course in a field relevant to that work.

The nearly two and three-quarter million specialists working in science and technology account for approximately 3.6 per cent of the civilian labor force. This figure was about 1.5 per cent in 1940 and is expected to reach 4.7 per cent in 1970.[4]

These persons serve the Nation in many ways: some of them expand scientific knowledge by doing research; some apply scientific information and engineering techniques to develop new products and services, or to solve problems in health, defense, or transportation; some operate complex systems for communication or for the exploration of space; and some educate and train manpower. The Nation's manpower in science and technology finds employment in each sector of the country; in colleges and universities, in industry, in Federal, State and local governments, and in other organizations.

## Manpower Supply and Utilization

Of the total manpower listed above, some four hundred thousand scientists and engineers in the United States are engaged in full-time research and development work. A breakdown of the number of personnel employed by the various sectors of the Nation is given below.

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[4] National Science Foundation, *Profiles of Manpower in Science and Technology*, NSF 62-23 (Washington: Government Printing Office, 1963), p. 3.

TABLE I

SCIENTISTS AND ENGINEERS BY WORK ACTIVITY
AND TYPE OF EMPLOYER
**(in thousands)**

| | Employer | | | | |
|---|---|---|---|---|---|
| Work Activity | Industry | Government | Colleges and Universities | Other | Total |
| Research | 55 | 15 | 50 | 15 | 135 |
| Development | 240 | 40 | 5 | 5 | 290 |
| | | | Total | | 425 |

SOURCE: United States Congress, House of Representatives, Select Committee on Government Research, Manpower for Research and Development, Study Number II (Washington: Government Printing Office, 1964), p. 17.

The above table indicates that industry employs approximately three hundred thousand scientists and engineers in research and development, while colleges and universities employ approximately fifty thousand personnel to perform the same function. The data also reveals that fifty-five thousand scientists and engineers are employed by the Government, which includes the Federal, State and local governments. But, although the Federal Government now performs or finances more than two-thirds of the research and development in the United States, insofar as the activities can be measured by expenditures, it cannot be readily determined how many of the total of scientists and engineers engaged in research and development are on the Federal payroll, directly or

indirectly.[5] What was evident in the testimony before this Committee was that a critical shortage of manpower is looming ever larger on the research and development horizon. For example, it is significant that the number of individuals capable of performing research and development increases by only 7 per cent annually, while the annual growth in Federal research and development expenditures has averaged 15 per cent.[6] This could also indicate that future Federal programs may be restricted by the availability of personnel.

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[5] United States Congress, House of Representatives, Select Committee on Government Research, *Federal Research and Development Programs*, First Progress Report (Washington: Government Printing Office, 1964), p. 12.

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[6] *Ibid.*, p. 12.

# CHAPTER V

## FEDERAL RESEARCH AND DEVELOPMENT: EXPENDITURES

One cannot claim that the amount of money a government invests in a particular enterprise represents the degree of power which its professional advocates exert. On the other hand, there is good reason to believe that spending levels afford a useful and meaningful indication, if not a precise measure. The research and development expenditures of all the Federal agencies are important, but national defense discussions logically center about the programs of the three agencies which are the largest users of research and development funds. These three agencies are the Department of Defense (DOD), the National Aeronautics and Space Administration (NASA), and the Atomic Energy Commission (AEC). The collective expenditures of these three agencies now amount to approximately 90 per cent of all the Federal funds utilized for research and development. A comparison of the expenditures for these and other agencies is presented in Table II.

A brief description of the research and development functions of these three organizations will be presented in this chapter, and in order of budget expenditures, their programs analyzed. The discussion of the Defense Department

will be brief in this section, since that department will be examined in detail in later chapters.

TABLE II

BUDGET EXPENDITURES FOR RESEARCH AND DEVELOPMENT
(In millions of dollars, for selected years)

| Fiscal Year | DOD* | NASA** | AEC | Other | Total |
|---|---|---|---|---|---|
| 1955 | 2,630 | 74 | 385 | 219 | 3,308 |
| 1960 | 5,654 | 401 | 986 | 697 | 7,738 |
| 1965 | 7,222 | 4,900 | 1,569 | 1,664 | 15,355 |

SOURCE: United States Bureau of the Budget, Federal Research, Development, and Related Programs, Special Analysis H (Washington: Government Printing Office, January, 1965), p. 460.

*Includes Civil Defense
**National Advisory Committee for Aeronautics prior to 1958.

## I. BUDGET TRENDS OF MAJOR AGENCIES

### Department of Defense

The DOD is currently spending the largest amount of Federal funds for research and development. Except for two years (1944-1945) in which the Manhattan project reached its peak expenditures, it has always been the largest user of these funds. As might be expected, the major increases have occurred in times of national crises with the largest increases occurring during World War II and the Korean

conflict. During the more peaceful years, DOD research and development expenditures have been characterized by relatively modest increases. Even so, the peacetime increases have been significant dollar amounts when considered in the light of the expenditures of the other agencies. Total research and development activities are expected to remain essentially stable between 1965 and 1966, with no apparent deterioration in the overall program. The primary defense research and development programs have been characterized by the continued effort to develop an anti-ballistic-missile capability; to perfect an enemy surveillance and detection system; to improve the antisubmarine warfare capability; and to improve the command and control system. The military programs are based on nuclear weapons; on missiles launched from land, water, and air; on a variety of manned aircraft; on nuclear-powered missile-carrying submarines; and on early-warning radar networks and satellites.

Major programs in the Defense area, for the past few years, have been getting just about all the money they can absorb within the limits of available manpower and contemporary scientific knowledge. Dr. Harold Brown, Director of Defense Research and Engineering, has stated:

> The budget is only one guide as to resource limitations. The research and development budget has been growing over the years at a faster rate than the supply of trained scientific and engineering manpower.

> We are in an era when competent manpower is perhaps a more limiting factor on operations than is money.[1]

## National Aeronautics and Space Administration

NASA was created in 1958 and given primary responsibility for research and development in civilian space efforts. It is now engaged primarily in civilian space application, but defense space efforts often overlap. For example, NASA has been granted authority and responsibility for the development of major boosters for space systems, and such boosters may have many uses in the future, both civilian and military.

Parts of the overall space program have been established specifically for the civilian aspect. However, a significant proportion of NASA's activities comes from the transfer of functions, personnel and facilities from the previously military-oriented space programs. Hanson Baldwin points out in a critical view of the space program:

> NASA was established by scientific-political pressure groups (with President Eisenhower's approval) advocating the theory that space efforts must be controlled by civilians and that space must not be used for military purposes. However, the most important applications of space technology have been military-reconnaissance satellites, weather satellites, missile-warning and navigational satellites.[2]

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[1] Fremont Ellsworth Kast and James Erwin Rosenzweig (eds.), *Science, Technology and Management* (New York: McGraw Hill, 1963), p. 53.

[2] Hanson W. Baldwin, "Slow-Down in the Pentagon," *Foreign Affairs*, XLIII (January, 1965), 30.

For Budget Bureau purposes, the entire program of the National Aeronautics and Space Administration is regarded as research and development. The current expenditures, which are predicted to stabilize at around five billion dollars annually, constitutes one-third of all Federal funds allocated for research and development. The primary efforts are channeled toward developing reliable high-thrust boosters and guidance and control equipment and techniques; research in materials, fuels, and behavior of man during space flights; experiments in communications over interplanetary distances; development of communications and meteorological satellites; and development of technology for later, more advanced flights to the planets.

Two-thirds of fiscal 1965's spending was scheduled for a single program: the Apollo moon landing and its related projects. In President Kennedy's decision regarding the establishment of a lunar landing mission, the similarity between the necessity for Presidential decision-making, such as this and the atomic and hydrogen bomb program, becomes obvious. In all these cases, the ultimate decision to pursue major technological and scientific goals costing billions of dollars was made at the topmost governmental level.

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The total outlay of Federal funds for space expenditures is expected to exceed $6.6 billion in fiscal year 1966. Without question, this is the largest single scientific and

technical endeavor ever undertaken by the American people. Defense Secretary McNamara observes that, "it will influence the course of science and technology, and, therefore, our national security programs, for decades to come."[3]

Over the four-year period 1961-1965, NASA's budget has increased by about 500 per cent. The momentum of on-going programs can now be maintained and new projects started without further significant increases in the total budget. This leveling in funds is expected to be realized by increased requirements in some areas being offset by reductions in others and by projects passing their funding peaks are completed, or are terminated. Although there are many ideas about how new areas should be explored, including the terminology that will be required if man is ever to fly to other planets, it is not considered likely that Congress will be easily talked into another big space effort, outside the current budget level, in the next few years.[4]

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[3] Robert S. McNamara, The Fiscal Year 1966-70 Defense Program and 1966 Defense Budget, United States Congress, House of Representatives, Armed Services Committee, Testimony (Washington: Government Printing Office, 1965), p. 135.

[4] The total space expenditures for NASA alone in 1966 is estimated at $5.1 billion, an increase of $200 million over the 1965 estimate. The greatest increase in 1966 expenditures is in the manned space flight development program, largely for services and equipment contracted for in prior years. Expenditures for facilities are estimated to begin to decline in 1966 as work in major portions of the manned lunar landing construction program is completed.

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Atomic Energy Commission

The research and development program of the AEC, including supporting construction, constitutes nearly half of that organization's total annual expenditures. Basic research is conducted in the physical and life sciences to secure a better understanding of nuclear processes and of the effects of nuclear radiation on living organisms. The AEC's applied research program includes efforts to improve the processes used in the production of special nuclear materials, to develop improved types of nuclear weapons, and to find ways of obtaining useful power from nuclear reactors. The AEC is responsible for the weapons development test program to meet the needs of the Defense Department for new and improved weapons. The Defense Department is responsible for weapon effects tests. Again, Baldwin observes:

> The political philosophy that nurtured the AEC was that atom bombs were too powerful to allow the generals to play with them; ergo, a civilian agency must control nuclear power--and it must be channeled away from nasty military purposes. The pragmatic absurdities of this point of view is now self-evident; nuclear power so far has been far more important in the military weapons and military propulsion field than in any other way.[5]

The DOD-AEC relationship is similar to the DOD-NASA relationship. Any programs taken together must mesh into a single, integrated national program; and, if Defense becomes

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[5]Baldwin, op. cit., p. 266.

involved, the project must hold the distinct promise of enhancing military power and effectiveness.

The research and development program in atomic energy appears to have reached a plateau in financing, with the possibility that expenditures could begin dropping in the next few years.[6] Development of new weapons has now been slowed by the United States-Soviet test ban, and industry is starting to take over the major role in development of power reactors. In many other areas where the AEC might turn its interest, a research program would, in all probability, overlap that of another agency.[7]

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[6] National Science Foundation, Federal Funds for Research, Development, and other Scientific Activities, Vol. XII, NSF 64-11 (Washington: Government Printing Office, 1964), p. 4.

[7] A slight decline in 1966 expenditures for the AEC development programs is expected due to reduced development in connection with the production of special nuclear materials and the achievement in 1965, of a readiness capability to resume atmospheric testing of weapons in the event of violation by others, of the limited nuclear test ban treaty.

# CHAPTER VI

## DEFENSE RESEARCH AND DEVELOPMENT: INFRASTRUCTURE

Before analyzing today's Defense research and development structure, a brief history of the growth of the organization that has evolved will be presented.

### I. BACKGROUND

Prior to World War II, the research and development activities of the Army and Navy were at an extremely low level. In 1940, for example, their expenditures were some thirty million dollars. There was no top-level organization to coordinate the programs of the two Departments; and, with the low level of activity, there was a correspondingly small professional competence in research and development in the Military Services. This situation was probably an important factor in the President's creating, in June, 1940, the National Defense Research Committee--a civilian organization with authority to initiate, and with funds to support, research and development directed at creating new weapons.

The establishment of this Committee was considered a constructive and essential step toward an immediate and effective application of science and technology to the art of warfare. Since World War I, in part because of limited

funds, the military had done little toward applying science and technology to warfare and weaponry. But as the possibility of war increased, it was decided that even the National Defense Research Committee was not sufficient. To increase the scope of activities, it was superseded by the Office of Scientific Research and Development in 1941. Throughout the war, this Office was the top authority and operating agency of the civilian scientific and technological effort. It could initiate research leading to weapons and carry the developments to the stage of operating models. But the War and Navy Departments tested and evaluated these weapons and judged their worth.

The military research and development expenditures grew to some six hundred million dollars in 1945. A twenty-fold expansion in a period of five years under war conditions had left little time for efficiency and economy. At the end of the war, and in conformity with the general and postwar demobilization of wartime agencies, the Office of Scientific Research and Development was discontinued in 1946. Its programs were appropriately assigned for disposition to the Army and Navy, who had expanded their facilities as the war had progressed. A Joint Research and Development Board was organized to coordinate all research and development of the two Military Departments. With the enactment of the National Security Act of 1947 and the creation of the

funds, the military had done little toward applying science and technology to warfare and weaponry. But as the possibility of war increased, it was decided that even the National Defense Research Committee was not sufficient. To increase the scope of activities, it was superseded by the Office of Scientific Research and Development in 1941. Throughout the war, this Office was the top authority and operating agency of the civilian scientific and technological effort. It could initiate research leading to weapons and carry the developments to the stage of operating models. But the War and Navy Departments tested and evaluated these weapons and judged their worth.

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Department of the Air Force, the task of coordinating the programs of the then three Military Departments was assigned to the Research and Development Board created by the same Act. This Board was made a party of the newly-established Office of the Secretary of Defense.

The Research and Development Board was a coordinating body that operated through a complex organization of committees, panels, and subpanels made up of part-time civilian consultants from academic institutions and industries and of representatives from the three Services. The usefulness of the Board was severely restricted due to its limited authority, its size, and its complexity.

By 1953, the research and development expenditures of the Department of Defense had risen to $1,700,000,000. In April, 1953, the Rockefeller Committee on Department of Defense organization recommended that a more effective organization be created to administer this large program.

In November, 1953, an Assistant Secretary of Defense (Research and Development) position was created, to be assisted by a Research and Development Policy Council, internal coordinating committees, and advisory panels. In December, 1953, the Assistant Secretary of Defense (Application Engineering) office was established, with the same advisory and assisting facilities as the Assistant Secretary. Operations of these two offices became difficult and confused

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because of the interwoven and inseparable nature of their function. In March, 1957, after attempts had been made for three years to coordinate, facilitate, and combine functions of these two offices, Secretary of Defense Wilson merged the two offices into the single position of Assistant Secretary of Defense (Research and Engineering).

Meanwhile, the rapid development of missiles had resulted in the creation of a Special Assistant to the Secretary of Defense for Guided Missiles. But, in November, 1957, Defense Secretary McElroy felt that the United States program had gone so far and had so many ramifications that he changed this Assistant's title to Director of Guided Missiles. The functions of this office included responsibility for all Department of Defense activities in research, development, engineering, procurement, and production of guided missiles.

The launching of Sputnik I by the Russians and the increasing publicity and claims of inter-service rivalry and duplication, as well as the cost of missiles and space research, precipitated the creation of the Department of Defense Advanced Research Projects Agency in February, 1958. McElroy decided to concentrate in one organization all the anti-missile and satellite technology undertaken within the Defense Department. The head of this Agency reported directly to the Secretary of Defense and was authorized to

direct such research and development projects within the Defense Department as the Secretary designated. Further authorization was granted to arrange for research and development work by other agencies of the Government, and to enter into contracts for performance of all work required to accomplish its mission. In practice, the Agency operated basically in three broad project areas:

1. Those too advanced to be included in specific service missions;
2. Those of concern to more than one service; and
3. Those which must be handled by an agency not subordinate to one of the services.[1]

By 1958, Defense research and development expenditures had risen to approximately $3.6 billion, with perhaps another $1.5 billion research and development-type work included in production programs. The many offices, agencies, and committees (which had been formed) created or permitted confusion, duplication, lack of overall direction, and inefficient use of sorely-pressed funds.

President Eisenhower sought to strengthen the control and supervision of the Secretary of Defense over the crucial fields of science and technology. Centralized management of research and development, he believed, would avoid duplication and prevent gaps in this program. The President

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[1]The Industrial College of the Armed Forces, "The Economics of National Security," Research and Development, Vol. VIII (Washington: Government Printing Office), p. 99.

proposed that the position of Assistant Secretary of Defense for Research and Engineering be upgraded to that of a Director and that the entire effort be placed under its control. It would be the job of this Director of Defense Research and Engineering to plan to meet the national military objectives instead of the more limited requirements of each of the Services. Programs which showed no promise or which were unnecessarily duplicative would be abandoned, while the promising programs would be released for development or production.[2]

As a result, on February 10, 1959, the Director of Defense Research and Engineering position was created to supersede the Assistant Secretary of Defense (Research and Engineering). Obviously, the functions of this new office created administrative problems and conflicts with respect to previously-created offices and agencies. The Director of Guided Missiles position was dis-established, and the research and development personnel transferred to the new Research and Engineering office. The responsibilities of the Advanced Research Projects Agency were redefined. The functions were to remain the same, but the Agency-assigned

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[2]United States Congress, House of Representatives, House Document No. 336, Recommendations Relative to Our Entire Defense Establishment, President's message (Washington: Government Printing Office, 1958), p. 38.

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[7] United States Congress, House of Representatives, House Document No. 366, *Recommendations Relative to Our Entire Defense Establishment*, President's message (Washington: Government Printing Office, 1958), p. 38.

projects were now to be subjected to the supervision and coordination of the Director of Defense Research and Engineering.

A chart depicting the organizational structure of today's Defense Research and Engineering effort is presented on the following page.

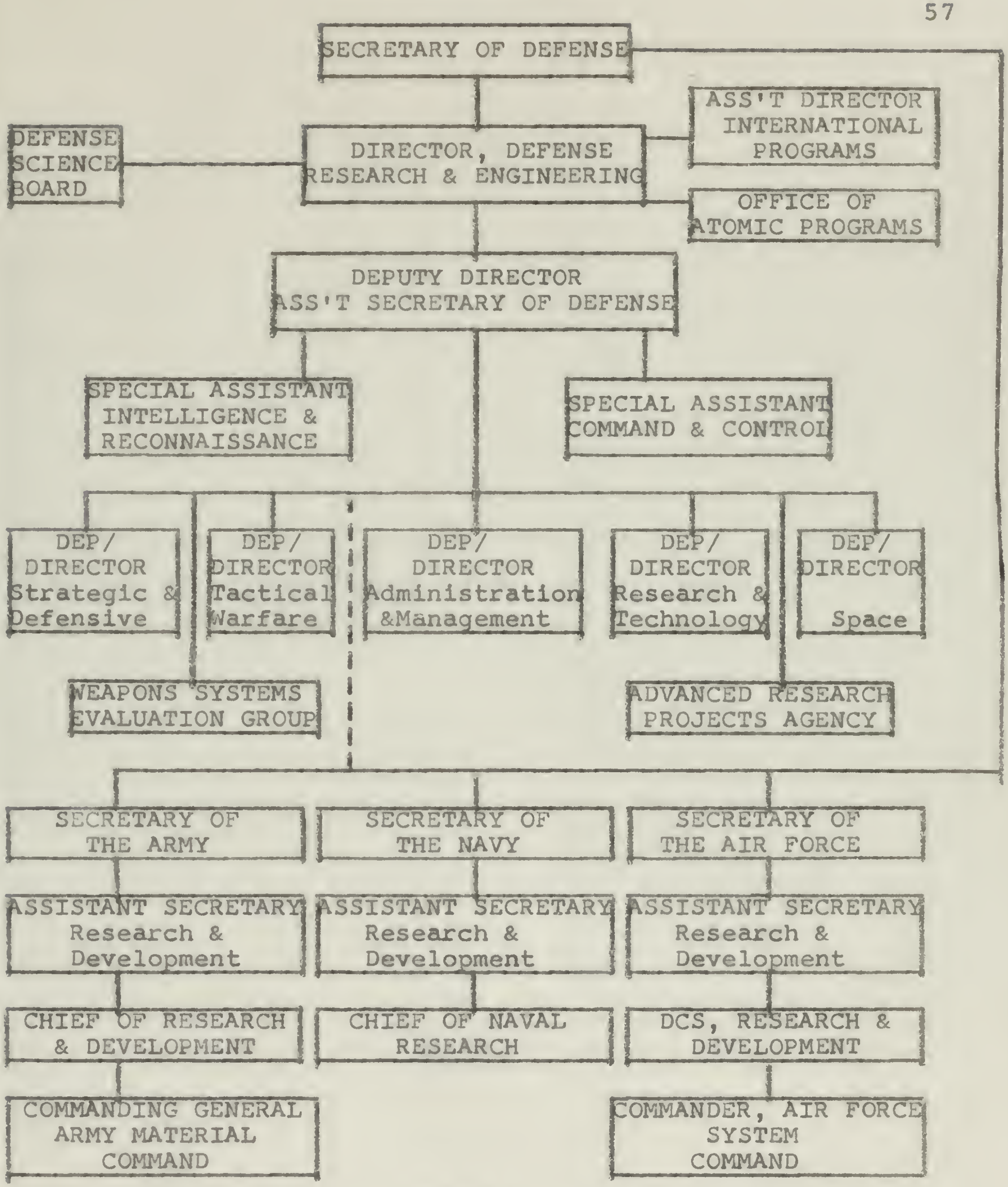
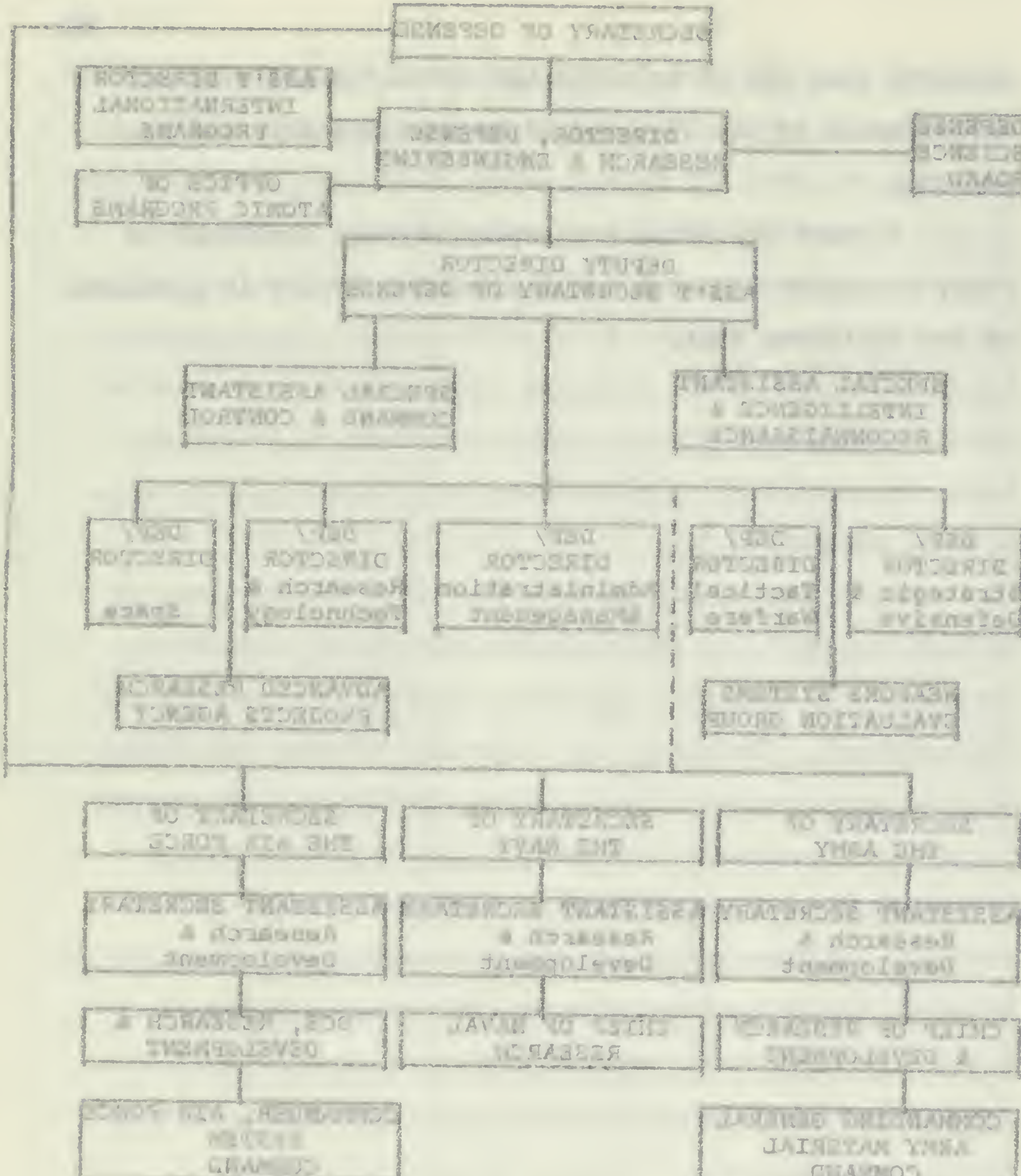



CHART 1

DIRECTORATE OF DEFENSE RESEARCH AND ENGINEERING
ORGANIZATIONAL CHART
(to the Development Command Level)

SOURCE: Donald W. Coble, "Does DDR&E Overcontrol?," Armed Forces Management, XI (October, 1964), 30.

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# CHAPTER VII

## DEFENSE RESEARCH AND DEVELOPMENT: OPERATIONAL PROGRAM

The Defense Department's program for research, development, test, and evaluation is concerned with providing future armed forces with superior weapons and equipment. The attempt is made to insure against an uncertain future by continuing to create a foundation of technology, knowledge, and experience sufficient to provide for contingencies as they materialize, or are identified. Factors that must be known to develop these requirements are the national security policy, the current threat, the potential threat, and the current state-of-the-art in various technologies, as well as how each factor is likely to evolve.

Current national security policy guidance is given by the President, the Secretary of Defense, and the Secretary of State. Intelligence agencies provide estimates on what the threat is or will be. The Joint Chiefs of Staff set forth the military requirements. Various inputs from the research and development community reveal levels of the state-of-the-art available.

Defense expenditures for research and development have increased approximately three-fold during the last decade. Total Federal expenditures for this purpose have

increased almost five-fold and are estimated to be about $15.5 billion for fiscal year 1966, or 15 per cent of the total Administration budget. This is a large sum which exceeds by several billion dollars the total military expenditures as late as fiscal year 1950. In fact, it is larger than the gross national products of most of the sovereign nations of the world.[1]

When the Defense Department allocates resources of this amount, it has to be mindful of the effect on the Nation. Consequently, defining the purpose of research and development programs inevitably carries with it some degree of influence by non-military and non-scientific factors. Not necessarily political or regional influences, but rather such considerations as ensuring existence of an aerospace industrial base or maximizing civil utilization are the factors that greatly affect research and development decisions made in the Defense Department.

It is always difficult to stop or redirect an ongoing program that was the result of a decision made in the past. It is also usually quite expensive. Some sixty major research and development projects were terminated during the

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[1]Robert S. McNamara, The Fiscal Year 1966-70 Defense Program and 1966 Defense Budget. United States Congress, House of Representatives, Statement before the House Armed Services Committee (Washington: Government Printing Office, February 18, 1965), p. 128.

last ten or twelve years, after costs of well over six billion dollars had been incurred. Early in 1961, Secretary McNamara became seriously concerned with the inadequacy of management disciplines and the attendant poor control over costs, performance, and schedules in Defense procurement--especially in research, development, and early production of major weapons systems. Cost overruns and schedule slippages had become the general rule. Large-scale weapon system developments, and even production programs, had been undertaken before requirements were clearly defined and before it had been clearly determined that the technology necessary to the development existed. All too often, insufficient attention was paid to how a proposed weapon would be used; what it would cost; and, finally, whether the contribution the weapon would make to military capability would be worth the cost, particularly in comparison with other, possibly competing, weapons.

Under the management techniques which are being implemented, the DOD embarks on a major new weapon system development only after what is called a pre-project definition study. This is one of the keys to the curtailment of the great waste of canceled programs. In the pre-project definition phase, the DOD, together with contractors, does the necessary thinking and planning and studying which permits better definition of the program, the more accurate

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assessment of technical risks, and more realistic determination of estimated costs and time required before a commitment is made to a full-scale development program.

In order to minimize waste and conserve talented technical manpower, big Engineering Development or Operational Systems Development projects are required to satisfy two criteria before being undertaken. First, the basic technology required must exist beforehand. Second, the proposed system must be of sufficient prospective military value to justify, at least, the development cost, and, in addition, the total systems cost should have a relation to its expected military value such that it has a fair chance of becoming part of the operating forces. Also, the total systems cost, as well as the development costs, should be understood very early in the program.

Needless to say, some wasted effort cannot be avoided, in the absence of perfect judgment and an impossible degree of foresight. There should always be more development programs underway than ever reach operational use. One reason for this is that it is desirable to have some insurance against technical and operational unknowns. Another reason is that it is often worthwhile to explore competing technologies. A third reason is to insure against technological surprise by potential adversaries.

## I. MANAGEMENT CATEGORIES

Problems, such as those discussed above, become more commonplace as a direct result of misguided management direction and emphasis. In order to insure the development and proper management of an adequate technological base for new weapons, it was concluded that there was need for a departure from the traditional concept of "research and development" as a single subject. This total field was, therefore, divided into six broad categories, which, in turn, highlight the fairly obvious fact that the different categories of work, which had previously been lumped as "R & D," needed quite different management techniques. The resulting categories modify somewhat the traditional concepts that were defined in Chapter III and indicate modification to facilitate application to the weapons system program. The Defense categories of research and development are:

1. Research;
2. Exploratory development;
3. Advanced development;
4. Engineering development;
5. Operational systems development; and
6. Management and support.[2]

All Defense Department research and development projects are fitted into one of these categories which are defined as follows:

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[2] "Hill Knife Poised Over R & D Requests," Armed Forces Management, X (April, 1964), 29.

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[2]"Hill Holds Potent User R & D Requests," Armed Forces Management, X (April, 1964), 59.

Research

Former Secretary of Defense Charles Wilson once offered the opinion that he did not care "what made the grass green." The barb was tossed at research for research's sake. Secretary McNamara evidently takes a slightly different view.

Research is used to describe the effort to achieve a basic understanding of natural phenomena and environment on which new ideas for military hardware may be based. Including both basic research and applied research directed toward the expansion of knowledge in various scientific areas, it represents the cost of developing new knowledge. Research is not pointed toward the solution of a specific military problem but does cover scientific areas in which experience and judgment leads to beliefs that there is a clear military potential. The combined research activities enable the DOD to benefit from the work of the non-government scientific community engaged in basic research, as well as to support research activities in in-house laboratories. These latter in-house efforts maintain an awareness within the Department of the significance of basic research advances as they pertain to future military technology. These bonds are very important to defense on a long-range basis, as important advances in military technology in recent years have stemmed from new results in basic science.

Research is most frequently done either in governmental laboratories or under cost-reimbursement contracts or grants with universities and absorbs approximately 5 per cent of the DOD research and development budget.

## Exploratory Development

This category consists of activities directed toward the solution of specific military problems short of the development of hardware for experimental or operational testing. The type of effort varies widely from investigations of physical phenomena with some application in mind, through studies, to development of minor components and breadboard hardware.[3] These efforts to support the evolution of ideas will normally be performed on a cost-plus-fixed-fee or incentive basis and receive approximately 15 per cent of the budget.

## Advanced Development

This category includes projects which have advanced to the point where the development of experimental hardware for technical or operational testing is required, prior to the determination of whether the item should be designed or engineered for eventual service use. It is at this stage

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[3]Along with research, this stage forms the pool of technical knowledge from which future weapons systems will be devised and designed.

that each project becomes identified with a specific military application or technique, and its potential military utility is questioned in depth. The costs of the more likely applications are explored to determine whether the potential operational benefit would be worth the cost of development, production, and deployment. Before advancing to the next category, engineering development, which is the most costly category of research and development in terms of returns, the project must undergo the "project definition phase." As mentioned earlier, it is during this phase that a proposed weapons system is defined with respect to performance, schedule, and cost. Based on the results of these findings, an informal decision can be made on whether to proceed with this system development or, if there are competing systems, which program to select. The process of objectively defining an undertaking before starting work is one that makes good sense regardless of the type of task at hand; however, in the case of the development of modern weapons systems, it becomes particularly important because of the great cost involved in such developments.

Actually, most weapon projects add only marginally to total combat strength; a few notable exceptions are the atomic and thermonuclear bombs and the Inter-Continental Ballistic Missile. Therefore, unless the potential payoff is obviously great, the DOD carefully monitors each step in

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the research and development cycle to reduce the number of expensive projects that may have to be terminated late in the development cycle.[4] The normal expenditures for the advanced development stage have been averaging approximately 10 per cent of the budget and are usually handled by means of incentive contracts.

Engineering Development

This category includes the effort directed toward the development of a particular system engineered for service use and for operational employment, but which has not yet been approved for production and deployment. A primary objective of this stage is to avoid commitment of each advance in materials or components to a specific weapon system when such an item should be developed for use by many systems. Before a project reaches this category, it has undergone the process whereby, with reasonable precision, a proposed weapon system is defined with regard to cost effectiveness, goals, milestones, and time schedules. Engineering development work is normally contracted for on a fixed price or an incentive basis and is allocated approximately 25 per cent of the budget.

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[4] Patrick W. Powers, A Guide to National Defense (New York: Frederick A. Praeger, 1964), p. 217.

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Operational Systems Development

The type of work done in this category is the same in an engineering sense as that done under the category of "engineering development." It is the effort directed toward the continued development, test, evaluation, and design improvement of projects which have already entered (or have been approved for) the production-development stage. This category normally consumes approximately 30 per cent of the budget. Contracts for systems development are on a fixed-price or incentive basis and may not be negotiated on a cost-plus-fixed-fee contract arrangement.

Management and Support

The final category groups together the effort in general support of the research, development, test, and evaluation program. It, thus, includes maintenance and overhead costs of the national ranges, such as the Atlantic, Pacific, and White Sands Missile Ranges. It also provides civilian manpower, technical materials and contractor assistance required for management and operation of the research and development organization. This category is normally allocated approximately 15 per cent of the budget.

In Research and in Exploratory Development, no constraints are placed on the extent of scientific and technology advancement which is hoped will be achieved. The high level of advancement desired and requisite high level

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The type of work done in this category is the same in an engineering sense as that done under the category of "engineering development." It is the effort directed toward the continued development, test, evaluation, and design improvement of projects which have already entered (or have been approved for) the production-development stage. This category normally consumes approximately 10 per cent of the budget. Contracts for systems development are on a fixed-price or incentive basis and may not be negotiated on a cost-plus-fixed-fee contract arrangement.

Management and Support

The final category brings together the effort in general support of the research, development, test, and evaluation program. It, thus, includes maintenance and overhead costs of the national ranges, such as the Atlantic, Pacific, and White Sands Missile Ranges. It also provides civilian manpower, technical materials and contractor assistance required for management and operation of the research and development organizations. This category is normally allocated approximately 15 per cent of the budget.

In Research and in Exploratory Development, no constraints are placed on the extent of scientific and technology advancement which is hoped will be achieved. The high level of advancement desired and requisite high level

of creativity causes inherent high technical risks with an expected high potential for failure. This work frequently requires long-term continuity without deadlines. It is essential that there be a high level of activity in these fields and duplicate efforts are frequently desirable. Much of this work is undertaken without regard to specific defense objectives and without government funding.

There has never been any argument about the need for sustaining the flow of new technology. Indeed, since 1961, steps have been taken to assure greater support of research and exploratory development, which are the foundations of new technology. In the DOD, the outlay for research and exploratory development has approached the $1.5 billion mark. This $1.5 billion-plus is spent for projects which are not required to have a detailed justification in terms of end use before approval. On the contrary, usually, fund research is planned on a level of effort basis, and it is only asked that general relevance be attained in exploratory development. Naturally good technical quality is desired in both areas, but the policy of attempting to create an environment conducive to creative work automatically inhibits overly-detailed management.

<u>Advanced Developments</u> are considered high risk because of the impossibility of predicting the degree of success in technological advancement or operational and

of creativity assist important high technical risks with an expected high potential for rewards. This work frequently requires long-term continuity without deadlines. It is essential that there be a high level of activity in these fields and duplicate efforts are frequently desirable. Much of this work is undertaken without regard to specific defense objectives and without government funding.

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Advanced developments are considered high risk because of the impossibility of predicting the degree of success in technological advancement or operational and

technical suitability at this stage. Hence, here also, there is frequently a need for multiple developments. There is an expected high rate of attrition among the multiple approaches in favor of one or more most suitable to enter future engineering development. Work in this field is also frequently undertaken without specific defense direction and without Government funding. It is highly desirable that the Government have an open door to consider, and use, and protect contractor innovations in development in this category. To keep this door open, these private innovations must continue to be protected.

Six hundred million dollars in the Advanced Development category are currently earmarked for innovations in experimental hardware. This money is intended for hardware developments which might evolve into large systems. About half of this is required to pass the test of good probability of evolution into new military systems. Thus, overall, nearly two billion dollars a year, in the Department of Defense are not subjected to the test of a high probability of immediate or clearly-foreseeable utility. That is not a paltry effort in the advancement of research and technology. It is, in fact, the greatest amount in the history of Defense research and development.

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which has been determined feasible either in laboratory or other experimental form. While the technical risk is considered relatively low, there is some risk inherent in the assumption that laboratory quantitative results can be engineered into final equipment. In short, it is from the first three categories--Research, Exploratory, and Advanced Development--that are acquired the "technical building blocks," i.e., the new technologies, process, materials, and critical components, that are needed for major systems development. A proper job of engineering development, or operational systems development, cannot be done unless these building blocks are available. Lack of attention to this principle and the resultant necessity to abandon large development projects on the ground of infeasibility have, in the past, been a major cause of unnecessary expense in development programs. While research and exploratory development does not necessarily have to be directly related to specific military requirements, a full-scale engineering or operational systems development can be justified only in terms of its potential contribution to a strategy, considering both its cost and its military effectiveness, as well as the relative cost effectiveness of other alternatives.

Fiscal year 1965 funding for the six categories defined above is presented for the four user activities of the Defense Department on the following page.

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TABLE III

DOD RESEARCH AND DEVELOPMENT FOR FISCAL YEAR 1965
(in millions of dollars, rounded off)

| User | Research | Development | | | | Management & Support |
|---|---|---|---|---|---|---|
| | | Exploratory | Advanced | Engineering | Operational | |
| Army | 89 | 244 | 71 | 754 | 56 | 183 |
| Navy | 149 | 337 | 176 | 226 | 345 | 218 |
| Air Force | 93 | 308 | 351 | 673 | 1,179 | 656 |
| ARPA* | 45 | 238 | — | — | — | — |
| Total | 376 | 1,127 | 598 | 1,653 | 1,580 | 1,057 |

SOURCE: James Camp Trainor, "Defense Research and Engineering: Annual Military Systems Review," Missiles and Rockets, XIV (March 30, 1964), 102-3.

*Advanced Research Projects Agency.

## CHAPTER VIII

## DEFENSE RESEARCH AND DEVELOPMENT: ORGANIZATION

The authority for the establishment of the position of Director of Defense Research and Engineering (DDR&E) is contained in the Defense Reorganization Act of 1958. He is to be a civilian appointed by the President and has precedence in the Defense Department immediately following the Secretary of Defense, the Deputy Secretary of Defense, and the Service Secretaries. Currently serving as the DDR&E is Dr. Harold Brown. Dr. Brown was born in New York City in 1927, and received his doctorate in physics from Columbia University. He has taught physics at Stevens Institute of Technology, served as Deputy Director of the Lawrence Radiation Laboratory at Livermore in 1950, and as Director in 1960. He has served on the President's Science Advisory Committee since 1958. Dr. Brown also served as senior science adviser to the United States delegation on nuclear testing in Geneva from 1958 to 1959. His fields are nuclear physics, reactor design, nuclear explosions, and weapons systems. He was appointed by President Kennedy to his present position in March of 1961.[1] Dr. Brown has recently

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[1]United States Congress, House of Representatives, Select Committee on Government Research, Federal Research and Development Programs, Hearings (Washington: Government Printing Office, 1963), p. 170. Although these

been named as prospective Secretary of the Air Force, to become effective on October 1, 1965.

## I. DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING

### Functions

The duties of the DDR&E are listed in three broad categories as follows:

1. To be the principal adviser to the Secretary of Defense on scientific and technical matters;
2. To supervise all research and engineering activities in the Department of Defense; and
3. To direct and control (including their assignment or reassignment) research and engineering activities that the Secretary of Defense deems to require centralized management.[2]

The first function consists principally of giving the Secretary of Defense scientific and technical information, advice, and recommendations on broad problems that often include many other important facets in addition to the technical ones. In this category, the proper technical

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qualifications speak well for his professional knowledge, Hanson Baldwin observes that "in his new political role in the Pentagon, he has become a remarkably unadventurous scientist." Hanson W. Baldwin, "Slow-Down in the Pentagon," *Foreign Affairs*, XLIII (January, 1965), p. 267.

[2] He could also assign a new weapons system, regardless of which service might have developed it, to any of the three Armed Services for production, procurement, and operational control. Harry Howe Ranson, *Can Democracy Survive Cold War?* (New York: Harper and Row, 1964), p. 87.

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questions concern the estimated technical performance of the systems and their potential for improvement, the validity of cost and time estimates for completion of development, and estimates on the development of possible weapons to counter or neutralize the effectiveness of the system, or comparison of capabilities with other systems. In his testimony to the House Committee on Government Operations on July 23, 1962, Dr. Brown stated:

> Questions of the military usefulness of the weapon, the political and psychological implications of having it or not having it and whether the country could afford it, are not matters of technical advice. While I may and usually do have opinions on some of these matters, I regard it as my responsibility not to confuse these opinions on non-technical matters with advice or opinions.[3]

The supervisory function is that of managing the research, development, test, and evaluation programs within the Defense Department. This function is one that has its impact on the Military Departments and the actual research and development projects being performed. The authority here is to approve, modify, or disapprove research and development projects and programs of the Military Departments, and other Defense agencies; to eliminate unpromising or unnecessary duplicative programs, and to initiate or

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[3] United States Congress, House of Representatives, Subcommittee of the Committee on Government Operations, Systems Development and Management, Part 2, Hearings (Washington: Government Printing Office, 1962), p. 441.

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[3] United States Congress, House of Representatives, Subcommittee of the Committee on Government Operations, Systems Development and Management, Part 2, Hearings (Washington: Government Printing Office, 1962), p. 511.

support promising ones. The formal overall procedures and techniques for screening and approving major development projects or groups of projects are related to a five-year program package concept. The DDR&E and the Assistant Secretary of Defense (Comptroller) work closely in developing and refining the technique for screening and approving major projects and, Baldwin claims that, "any projected weapons system has to run the gauntlet between the Scylla of Dr. Brown and the Charybdis of Mr. Hitch."[4] The authority, of course, is derived from the Secretary of Defense and in problems of major importance, the DDR&E actions are in the form of recommendations to him.

The last function, the direction and control of research and engineering activities deemed to require centralized management, is the function that is carried out through the operations of the Advanced Research Projects Agency, which reports directly to the DDR&E. A Weapons System Evaluation Group is also assigned to the administrative control of the DDR&E and is supported by the Institute for Defense Analysis. These groups provide operations analyses of weapons systems to the Joint Chiefs of Staff, to the DDR&E, and to other components of the Office of the Secretary

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[4]Baldwin, op. cit., p. 274.

of Defense. All three subsidiary organizations will be discussed in detail later in this paper.

The missions of the DDR&E office can be summarized as ensuring that:

1. A technological base is available for current developments and is replenished for future ones that may be needed later as national purposes and strategies evolve; and to establish maximum carry-over of technicians to the civilian sector of the United States economy.
2. A balance is struck in the allocation of resources within the sometimes conflicting requirements of dollar limitations, military needs, impact on civilian economy and other demands on strategies.
3. Planning of the research and development program as a whole and adherence to the plan is firm enough to minimize uncertainty in the budgetary process in the Military Departments and in the defined industry, but flexible enough to accommodate desirable changes.
4. Developments are pursued which will result in military systems that best support the purposes and strategies of the United States and its allies, as distinguished from development which, while technologically feasible or otherwise attractive, may be of limited worth.
5. Individual projects are planned and controlled in relation to the plan so that military systems are operationally available when needed, with the desired performance and within the intended costs.

The ideas for new research and development can come from any individual or organization, civilian or military; if the resulting proposals fulfill any military requirement or defense research objective, they may become identified with a specific project. There is no established or rigid pattern for the initiation of a weapon project, although the

management of the development is carefully monitored within the Defense Department so that the program objectives can be fully met.

The importance of assigning the best possible personnel as managers of research and development programs cannot be overemphasized. The present procedure under which military officers are given such an assignment in the normal rotation process, without enough consideration of each man's qualifications for the position, has recently been criticized by the House of Representatives Committee on Appropriations.[5] This committee expressed concern that the above procedure could lead to the man assigned merely becoming a figurehead with a civilian deputy actually managing the program. It questioned the need for the manager of a project being a military man in order to give the program the desired input of professional military experience if this same input could be derived from a lesser position of authority. If the Defense Department cannot improve their present policy regarding the rotation of military personnel, it was recommended that more development programs be managed by civilian personnel who can stay on the job until it is finished.

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[5]United States Congress, House of Representatives, Appropriations Committee, Department of Defense Appropriations Bill, 1966, Report (Washington: Government Printing Office, 1965), p. 45.

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Since the assignment of the responsibility for a program is often impossible under a system in which managers are frequently reassigned, with the subsequent problems of fixing responsibility, effective management becomes an almost impossible task. While the DDR&E is the Defense agency primarily responsible for the program, the above conclusion is particularly applicable to the staff of operational organizations in each of the three Services. A resumé of the organizational concept of these three Services will be presented to investigate the principles employed to attempt to achieve the desired managerial control.

## II. ARMY RESEARCH AND DEVELOPMENT

The role of the Army in national defense has undergone an important change within the past several years. Following the development of the atomic bomb and thermonuclear weapons, national security was based primarily on the concept of massive retaliation. This approach led to a downgrading in the size and mission of the Army's forces and placed greater reliance on large-scale systems of strategic deterrence, utilizing aircraft and missiles. However, in recent years, the national security policy has changed with the recognition of a need for effective and mobile forces to deal with a variety of conflict situations ranging from limited brush fires to all-out war. This recognition has

reemphasized the Army's mission, one geared to conflict at less than a massive global level. For weapon system acquisitors, the Army has continued to adhere to the arsenal concept, maintaining strong in-house technical and managerial capabilities.

In the most recent reorganization of the Army, the Army Material Command was established to integrate the material functions, and is similar to adaptations which have taken place in the other Services. The Army has maintained strong centralization over the managerial functions with emphasis lying in the rise of vertical project management. Limited delegation to private industry is the rule, and in those instances where outside private contractors have been utilized for technical or systems advice, these facilities have remained in a definite staff capacity with no direction over other contractors. When there has been a question of a lack of manpower to meet total needs, the Army generally maintains the more complex and advanced programs for in-house effort and has contracted out the more standardized programs. This approach is followed to ensure an advanced state-of-the-art for in-house capabilities.[6]

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[6]Fremont Ellsworth Kast and James Erwin Rosenzweig (eds.), Science, Technology and Management (New York: McGraw Hill, 1963), p. 77.

## III. NAVY RESEARCH AND DEVELOPMENT

The mission and role of the Navy also have undergone significant changes in the past several decades. The Navy had long been considered the Nation's "first line of defense" against conventional warfare. With the development of nuclear capabilities by potential enemies, this role was diminished somewhat. The importance of the Navy's mobility in meeting limited war conditions has since been emphasized. Experience in Korea, the Formosa Straits, and now in Vietnam supports the importance of this role and, particularly, the carrier task force as an instrument of limited war capability.

However, it took a revolutionary new development to change the Navy's basic mission. The development of the Polaris, the Navy's Fleet Ballistic Missile system, provided the Navy with a new weapon of strategic importance. It has become an integral part of the total system of strategic deterrence. The Polaris program also represents one of the major weapon systems development of today, comparable in size and scope, and perhaps greater in cost than the atomic or hydrogen bomb programs.

The Navy has made major adjustments in its pattern of organization structure in order to provide for the performance of functions under an integrated systems management concept. The need to integrate on a weapons system basis

led to the merging of two of the major Navy Bureaus, the Bureau of Ordnance and the Bureau of Aeronautics, into a Bureau of Naval Weapons in mid-1959.

In its Office of Naval Research, the Navy adjusted its internal managerial structure to provide for coordination of the various functional activities. This was done through the lead-bureau concept or by the establishment of a separate agency for managerial and technical integration, such as the Special Projects Office for the Fleet Ballistic system. Under these arrangements, the lead-bureau or special office is given over-all responsibility for weapons system management.

The Navy has made extensive use of outside contractors for technical direction on a staff advisory basis with limited authority over other contractors. It has maintained fairly strong central control and in-house authority, with limited delegation of the systems management functions to private enterprise. In the areas of research, development, test, and evaluation, the Navy continues to provide strong in-house capability.[7]

## IV. AIR FORCE RESEARCH AND DEVELOPMENT

The development of strategic bombing during World War

[7] *Ibid.*, p. 135.

revolutionized modern warfare. The atomic and hydrogen bombs provided strategic weapons of momentous proportions, and the Air Force was assigned the role of conveying these weapons. The national policy of a nuclear deterrent gave a prime role to the Strategic Air Command and the development of such weapon systems as the B-47, the B-52, and the B-58. As ballistic missiles became a growing part of the strategic arsenal, the Air Force also was assigned major responsibility for their development and utilization.

The Air Force stresses the weapon system concept and has moved in the direction of systematic integration. Early in 1961, two steps were taken that represented a major change for the Air Force. On March 6, 1961, Secretary of Defense McNamara issued a Directive "Development of Space Systems," that outlined the responsibility of the various Services in the military portion of the national space program. Specifically, this directive assigned the Air Force the responsibility for research, development, testing and engineering of the Department of Defense space programs.[8] In effect, this directive made the Air Force the systems manager for the military space program. However, this directive left the door open for other military agencies to

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engage in preliminary research and to develop new ways of using space technology. Those functions performed for military space systems by the Air Force are complementary to the Nation's civilian space exploration efforts, which are the prime responsibilities of NASA.

To facilitate implementation of this newly-assigned responsibility for management of the military space program and to coordinate with NASA as well as with the Army and the Navy, the Air Force undertook a sweeping reorganization--another evolutionary step toward integrated systems management. Basically, the Air Force concentrated development and procurement of all systems--space, aeronautical, electronic, and ballistic--into a single command, the Air Force Systems Command. This concentration under a single head facilitated technical integration and management control. The Systems Command is organized to provide the most up-to-date and effective management of Air Force scientific and technical resources, and is the single manager of all aspects of acquisition of weapon and related equipment from research and development through procurement.

The Air Force has traditionally delegated more responsibility for design and engineering to private industry than have the other two Services. Under its weapons system concept, it has delegated broad responsibilities to industry. For many programs, it has given the prime contractor

technical direction and systems-integration responsibility. It also utilizes separate contractors, such as Space Technology Laboratories and Aerospace Corporation for systems integration and technical direction. Recently, the Air Force has been stressing the importance of in-house capacity, particularly central planning and direction for the various laboratories for weapons system management, by establishing a research and technology division within the Air Force Systems Command.[9]

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[9]Kast and Rosenzweig, *op. cit.*, p. 178.

CHAPTER IX

DEFENSE RESEARCH AND DEVELOPMENT:

SUBSIDIARY ORGANIZATIONS

William Kaufmann observes in his book, The McNamara Strategy,

> McNamara brought about two major revolutions within the DOD. He redesigned the military strategy and forces of the United States and at the same time he installed an entirely new method of making decisions within the Pentagon.[1]

The 1963 budget for the military functions of the DOD was the first to be developed under the procedures introduced by the McNamara regime. No longer would the Defense budget be split according to Service requirements but instead be divided up among nine program packages, one of which is Research and Development. Each package contains those military programs which contribute to the same function irrespective of their particular Service alliance. The new procedure, which represents the largest step toward the unification of the Armed Forces since the National Security Act of 1947, also features five-year cost projections, measurement of all input costs based upon systems analysis, and

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[1] William W. Kaufmann, The McNamara Strategy (New York: Harper and Row, 1964), p. 3.

estimates of the relative worth of each program and its elements in achieving national defense objectives.[2]

A Project Definition Directive issued in March, 1964, outlined the stringent prerequisites future weapons systems would have to meet. Specifically, DDR&E insisted that before a systems development program is initiated the technology must be proven. All major unknowns, such as components, sub-systems, costs, schedules, and reporting procedures will have been eliminated, insofar as possible before development is approved. Concurrency, except in the rare case of preeminent national defense interest, has been rejected as a method of development.

A second, no less major change is that newness _per se_ is not a criterion for development. The contribution of a proposed weapons system to over-all national defense must be clearly demonstrable, and it must be proven beyond dispute that the job cannot be done by a system already in the inventory.

DDR&E is also concerned with its communication with private industry. In past relationships, industry was influenced by the wishes of the Services, rather than the hard, definable direction that military technology was taking.

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The recommendation that has been advanced is that industry should tell the military what it needs! More specifically, DDR&E feels that defense-oriented firms are in a unique position to tell the Services what the state-of-the-art is and what, therefore, the military can reasonably ask for.

How are decisions and recommendations, such as these, made? To answer this question, a look at the workings of DDR&E is in order. Since March 1, 1964, the programs which DDR&E have concerned themselves with are grouped into five areas, each headed by a Deputy Director.[3] This organization, including both the Weapons System Evaluation Group and the Advanced Research Projects Agency is staffed by 180 professional civilians, 153 military technicians, and 228 clerks, both civilian and military. Although Deputy Directors have been named for each of the major areas of DDR&E concern, projects are assigned on an individual basis rather than by any rigid adherence to an organization chart. DDR&E is designed to work informally. There are frequent meetings with Service counterparts and working drafts of memoranda are prepared by the Services so that once the language is fully worked out, the papers can be sent to DDR&E with some assurance that they will be accepted. An attempt is being made to change from the pre-Brown DDR&E when the Services

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[1]See organization chart, *supra*, p. 57.

would submit a paper only to have it bounce back for some minor change in language; there was no assurance that once this was corrected, the correspondence would not be returned again. The review-and-approval cycle in the Office of the Secretary of Defense had been described by all three Military Services as having the "yo-yo" effect. A new idea was sent up the line to DDR&E, who reviewed it in some detail as the contributor had. Frequently, DDR&E would ask the contributor to do some more homework on the idea; the additional work was done--and the cycle sometimes repeated itself.[4]

Since DDR&E cannot control the Military research and development effort in detail, it tries to control the environment within which that program must work. The tendency is to take care of emergencies, either the very big programs or the ones that either DDR&E, Congress, or the President considers very important, or the ones that are in trouble. The goal is to set up clear-cut procedures within which the Services can make decisions. By periodic program reviews, the over-all content of the research and development effort can be controlled. There are two major reviews each year. The first is the submission of the program and supporting information for the coming year's budget. The next review

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[4]Defense Science Board, Subcommittee on Defense Contractor Effort, Encouragement of Innovation, Report (Washington: Government Printing Office, 1964), p. 9.

takes place after Congress acts on the research, development, test, and evaluation program; it requires the Services to support their requested allocation of funds before they are released. The DDR&E staff reviews these program plans and the funding requests and recommends action to Dr. Brown, who, in turn, makes recommendations to the Secretary of Defense. Through change proposals, by which any major component of the DOD may alter its proposed program, reviews of technical development plans, and liaison with the Military Services and their contractors, the Staff maintains continuous review of the research and development programs.[5]

Under existing procedures, the personnel of the Office of DDR&E must assume too often a primarily negative role in their review of proposals of the Military Services. It seems reasonable that with the existing negative roll of the Comptroller's office, DDR&E could undertake a more active part in expediting the successful completion of approved development programs. The lengthy testing and evaluation procedures now employed by the Military Services, coupled with the ever-present reluctance of engineers and technicians to stop attempting to make "just one more" refinement in a system, could tend to reduce the chances of

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It also seems reasonable to expect that military research and development programs which have been funded in amounts of between $6.5 and $7 billion for several years should provide significant new weapons and equipment. While new items have recently been added to the inventory, the quantity and quality of these systems are hard pressed to justify the massive effort being funded. The management tools instituted by the DOD may not stifle the development of new programs, as has been alleged, but it can be argued that a sufficient number of new programs of major importance have not been forthcoming. The DOD is, therefore, under constant pressure to institute procedures designed to maximize the deployment of new and better weapons and equipment with the operating forces.

Apart from the Advanced Research Projects Agency, Dr. Brown has no line authority over the research and development efforts of the Services. His is primarily a staff function of recommending courses of action to the Secretary of Defense. However, his influence, both in this role and in actions delegated to him by the Secretary of Defense is not inconsiderable. He has stirred up considerable furor in the Pentagon by increasingly giving the Services what he calls "general technical guidance" on individual projects,

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and even more detailed instructions on how they should conduct their research. In spreading out into the operational area, his office has, in the case of the TFX, gone so far as to lay out specifications and performance characteristics of the new weapon system. The Military objects to his advice by saying: "How do you know what kind of a plane we want? You have not flown in combat. We have, and we know what we need." Brown's usual rejoinder comes back like this:

> The qualification this gives you is to say what characteristics are best in an airplane, not what is to be done to obtain them. Military requirements must be cast in terms of, "If technology allows so-and-so to happen, we want it to do this"; it should not be cast in terms of, "This is how to achieve such-and-such characteristics."[6]

How to get technology to allow so-and-so and how to recognize it is accomplished by the Advanced Research Projects Agency (ARPA), the Weapons Systems Evaluation Group (WSEG), and the Institute for Defense Analysis (IDA). Each of these subsidiary organizations will be analyzed separately in the remainder of this chapter.

## I. ADVANCED RESEARCH PROJECTS AGENCY

ARPA celebrated its eighth year of existence in February, 1965, and the adult looks very little like the

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[6] "Planners for the Pentagon," Business Week (July 13, 1963), 47.

infant. This agency, which once handled the DOD's space programs[7] and was very hardware oriented has turned into a rather scholarly organization which brings a somewhat more basic research approach to most of the vital defense questions facing the nation. With an authorized staff of sixty-eight professional civilians, fifty-six military technicians, and sixty-three clerks, civilian and military, ARPA exercises the functions of directing and controlling line operations. ARPA is responsible for the basic and applied research and development in such advanced projects as are assigned by the Secretary of Defense or by DDR&E, and utilizes military departments, other government agencies, industrial and commercial facilities, individuals, and educational or research institutions to carry out its projects.[8] Generally, an assignment to ARPA results from a decision that centralized management of a program in the Office of the Secretary of Defense is desirable or from a determination that the contemplated research is not peculiar to one Service or identified with a specific category of military systems. This agency provides the Secretary of Defense with a full-time, quickly-responsive, highly-competent technical

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[7]The three broad project areas are listed supra, p. 54.

[8]Patrick W. Powers, A Guide to National Defense (New York: Frederick A. Praeger, 1964), p. 214.

and managerial body to direct and accelerate high priority military research which requires close attention at the Secretary of Defense level.[9] The goal of most projects is to determine the feasibility of a technique or of a system. Once this feasibility is established, the projects are usually transferred to one or more of the Military Departments to continue the development and exploitation of the results of ARPA's research.

Research areas in which ARPA has current responsibility are:

1. Ballistic Missile Defense. Also called Project DEFENDER, this area absorbs nearly half of the ARPA annual budget and involves the efforts of about 25 per cent of the technical personnel. This project is concerned with the scientific and technical knowledge needed for the design of the United States defenses against ballistic missiles and satellites, and for the assessment of the ability of the United States ballistic missile systems to penetrate enemy defenses.

2. Nuclear Test Detection. Referred to as Project VELA, this program calls for ARPA to conduct research, development and systems design to improve United States capability to detect, identify, locate and verify the occurrence of nuclear blasts in space, the atmosphere, underground or underwater.

3. Remote Area Conflict. This program, commonly called Project AGILE, is founded on the thesis

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[9] After DDR&E, ARPA is perhaps most directly affected by the decisions of the President's Scientific Advisory Committee. James Camp Trainor, "Defense Research and Engineering: Annual Military Systems Review," Missiles and Rockets, XIV (March 30, 1964), 36.

that remote area warfare is controlled in a major way by the environment in which it occurs. It is designed to support the solution of remote area conflict problems with primary emphasis on requirements of indigenous forces in guerrilla warfare situations.

4. Behavioral Sciences. Known as Project CARINA, this program is almost exclusively basic research conducted by universities and non-profit corporations. Research is supported in the areas of human performance, motivation, and teaching and learning.

5. Information Processing Techniques. A project designed to increase the usefulness and effectiveness of digital information processing.

6. Energy Conversion. This program includes a look at fuel cells, magneto-hydrodynamics, thermochemistry and the like, for possible ground and satellite use. ARPA has supported research in this area, but subsequent to fiscal year 1965, the Services will follow up this work and will be solely responsible for the funding of research in energy conversion in the DOD.

7. Propellant Chemistry. In this program, called Project PRINCIPIA, ARPA conducted research in the discovery and development of new high energy chemical propellants. Reaching the theoretical limits in a number of propellants, both solid and storable liquid, the next step is to harvest this information for practical use. This work is now being divided up among the individual Military Services.

8. Material Sciences. Named Project PONTUS, this program consists of basic research in materials. The major effort is conducted in twelve civilian universities.

Except as noted above, these programs will probably remain with ARPA for several years, although there are constant changes within the programs themselves. A continual analysis of current programs provides the basis for deciding

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which projects have reached the state where they can be farmed out. The character of ARPA demands that completed programs be terminated, in order to allow the assumption of new projects.

## II. WEAPONS SYSTEMS EVALUATION GROUP

Although operations research was active prior to World War II, it was not until the war that it really proved effective. James Forrestal, the first Secretary of Defense, found that he was presented with problems the Military was not qualified to solve--primarily in the fields of applying technology to military adaptation. To insure a capability for impartial evaluation of weapons systems, he created, in December, 1948, the WSEG. Today, this Group is staffed by two professional civilians, fifty-four military technicians, and fifty-one clerks, civilian and military. The WSEG provides comprehensive, objective, and independent analysis and evaluation of weapon systems under projected conditions of war. It studies present and future weapons systems, their influence on strategy, organization, and tactics, and their comparative effectiveness and cost. In other words, the WSEG brings together the proposed weapons and the proposed employment to see if they will be effective for the type of warfare predicted for the future. This is called an "operations analysis" program, although it involves many unknown

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factors that cannot accurately be determined. It can, through the use of rapid computing techniques, be used to determine the critical characteristics of weapons and materiel that best meet future needs.[10]

The importance of the WSEG lies in its unique combination of experienced military officers working next to experienced academicians within the DOD. The WSEG's position within the Defense establishment is a valuable asset also. In conducting a study, the Group can call for--and get--information from any of the Services or any of the Defense agencies. Intellectually, the Weapons System Evaluation Division (WSED) of the Institute for Defense Analysis, is an integral part of the WSEG. It is co-located with the DOD organization and the two groups work side-by-side in many instances. The military officers of the WSEG are assigned to various projects, usually two to a project, and work with the WSED staff.

Although the WSEG is under the surveillance and direction of the DDR&E Chief, Dr. Brown, its study requirements can come from DDR&E or the Joint Chiefs of Staff, or from the Secretary of Defense himself. These studies vary in size and requirements, ranging from a rather brief month-long exercise to a continuing survey of particular areas, such

[10] Powers, op. cit., p. 215.

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[10] Powers op. cit., p. 215.

as the state-of-the-art in Lasers. Generally speaking, they involve systems analysis and operations research into the merits of weapon systems or competing weapons with respect to operational use, relative costs, effectiveness, and limitations.

One of the main rewards of working for the WSEG/WSED is that the papers, studies, and verbal information the organizations are asked to prepare are transmitted quickly to the top levels of the Defense establishment, where they could carry considerable authority.

## III. INSTITUTE FOR DEFENSE ANALYSIS

IDA was born in 1955, when Defense Secretary Charles E. Wilson asked the Massachusetts Institute of Technology (MIT) to take on the civilian staffing for the Pentagon's WSEG. Civil Service had been inadequate for the task of supplying the scientific knowledge required by that Group. MIT felt the task was not one for a university, but agreed to join with other universities to sponsor a private, non-profit corporation to furnish professional service to the WSEG. The California Institute of Technology, Case Institute, Stanford, and Tulane joined MIT, and set up IDA with a $500,000 Ford Foundation grant as initial working capital. Six more universities have since joined--Chicago, Columbia,

Michigan, Pennsylvania State, Illinois, and Princeton. The objectives of IDA are three-fold:

1. To enable and assist the academic community in placing its resources in relevant, effective and contributing apposition to the Government;

2. To build the competence of this new science of Operations Research by increasing the number of people engaged in it and by developing the skills thus exercised; and

3. To transmit to the Nation generally, through channels of teaching and communication, a sharpened appreciation of the real and present problems of preserving the national security.

Originally established in connection with the evaluation of competing weapons systems, the scope of the Institute now encompasses broad areas of military strategy where the support for judgments on weapons evaluation is often found. It even would appear that now the close connection with strategic issues has been the link that has extended research on military operations into the far reaches of national policy.

The largest and still major contract of IDA is to provide technical support and studies to the WSEG. The second major task that IDA took on historically was to provide support for ARPA when it was founded. Mr. Richard M. Bissell, Jr., President of IDA, admitted in 1962 that since ARPA, in a sense, has been subsumed under DDR&E, IDA was now a support or contract agency for the DDR&E itself, as well

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as for ARPA.[11] At that time, IDA employed 226 professional employees and some 141 non-professionals. IDA's current contracts add up to approximately ten million dollars.

IDA now has four other divisions: Research and Engineering Support, International Studies, Communications Research, and Jason. The Research and Engineering Division is under contract to DDR&E for technical studies of the physical sciences and engineering of such depth as to be unsuited for the WSEG. By design, this Group is composed of senior scientists, who function as "intimate" consultants to the DDR&E.[12] The International Studies Group has done studies for the State Department and for the Arms Control Agency. The Communications Division, located on the Princeton campus, does classified research in the area of electronics for the DOD. Jason represents one of the most interesting activities of IDA. This group was created as a consequence of a belief on the part of older scientists that the younger generation was not being exposed to the key unsolved problems of the Nation's defense. Basically, the group, consisting of twenty-five to thirty young scientists, meets for about six weeks each summer to be exposed to

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[11] United States Congress, House of Representatives, Subcommittee on Government Operations, Systems Development and Management, Hearings (Washington: Government Printing Office, 1962), p. 618.

[12] Trainor, *op. cit.*, p. 40.

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[11] United States Congress, House of Representatives, Subcommittee on Government Operations, Systems Development and Management, Hearings (Washington: Government Printing Office, 1962), p. 518.

[12] Trainor, op. cit., p. 40.

defense problems. They are accorded the widest need-to-know and are briefed by the three Services, DDR&E, and the major agencies of the Government. After that, they are free to form work teams, think about these problems and research them.

The organization chart presented on the following page illustrates the relationship of the DDR&E and IDA, as well as WSEG and WSED.

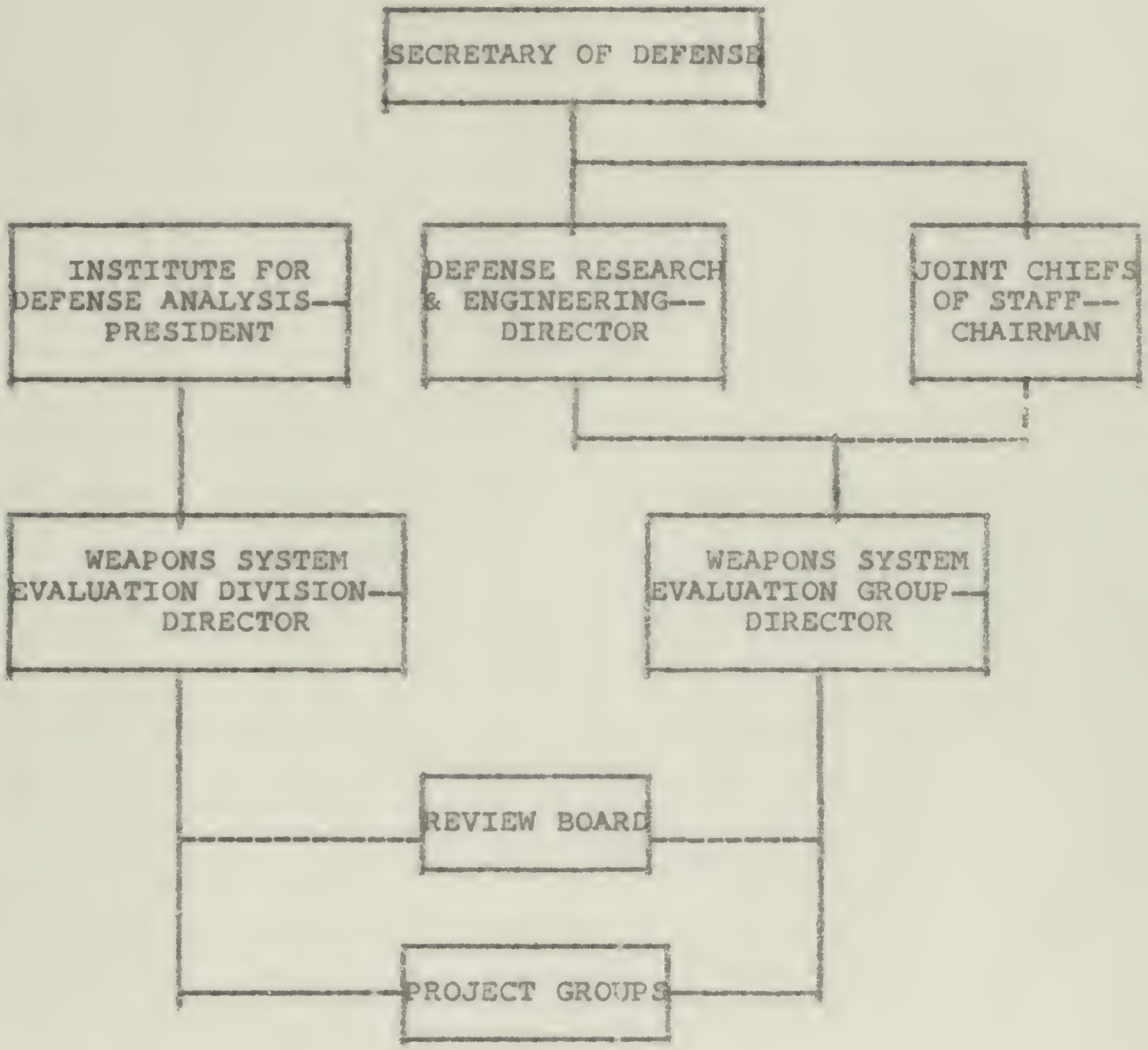


CHART 2

RELATIONSHIP OF DDR&E AND IDA, AND WSEG AND WSED

SOURCE: "Weapons Systems Evaluation Group," Armed Forces Management, XI (November, 1964), 74.

CHAPTER X

# DEFENSE RESEARCH AND DEVELOPMENT: DATA UTILIZATION

The preceding chapters have described the organizations established for the conduct of research and development within the Defense structure. Obviously, this effort would be wasted if data on the results achieved were not either passed on and utilized by policy-makers or made available to other organizations that would benefit from knowledge of this information. Scientific and technical information is both a principal ingredient and a major product of research and development. As science and technology have expanded, so have the volume and complexity of the interchange of scientific information. The Defense Department recognizes that as a major sponsor of the Nation's research and development effort, it also bears the collateral responsibility to assure that the fruits of such endeavor are made available to the scientific community and others.

## I. DOCUMENTATION CONTROL REORGANIZATION

### Defense Documentation Center

In 1955, the Armed Services Technical Information Agency was created, to operate under Air Force management.

This agency was the control depository for the DOD research, development, test, and evaluation activities. Recently, the responsibility for management control of scientific information has been assigned to the DDR&E. The old agency was given a new name, a new home, and completely revamped. The Armed Services Technical Information Agency was redesignated as the Defense Documentation Center to reflect more precisely its mission and functions. The Defense Documentation Center for scientific and technical information was transferred to the Defense Supply Agency at DDR&E initiative which is deemed an all-around improvement. Not only has the scope of document collection been expanded to include restricted-data documents, but the Center has also been assigned the functions of maintaining a clearinghouse index of current research development, test and evaluation programs within the Department as well as establishing a centralized directory and referral service on scientific and technical information activities. Since the Defense Supply Agency is responsible directly to the Office of the Secretary of Defense, the channels of communication between policy and operations are drawn much closer with the new arrangement.

A new automated system has been initiated to make information more readily available which should reduce unnecessary duplication in research and exploratory

development. Called the Research and Technology Resumé, it will be utilized for reporting progress on current projects. These reports are prepared in a standard digital language which permits their rapid and proficient interchange among Military Services and Defense agencies, and, by special agreement, with NASA.

The Defense Documentation Center receives, stores, and disseminates information emanating from the Defense Department, other governmental laboratories, and from industry. Some analytical work is done within this organization to help people understand certain information better, but the whole process is a difficult job because of the tremendous number of documents involved. Security problems, with respect to the large number of customers--domestic agencies, close allies, and other foreign countries--as well as questions of proprietary information also help confuse the issue. In March, 1965, the DOD issued a new instruction to provide uniform policy guidance for security classification of official information. Application of its provisions is expected to reduce the quantity of classified information and material, thereby facilitating the flow of scientific and technical information and Defense-developed material into non-Defense activities.[1]

[1]"Security Guide is Issued," Naval Aviation News, NAVWEPS No. 00-75R-3 (March, 1965), 38.

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Data Control Necessity

One could question whether this activity is worth the money and manpower that is being put into it. Congress has become increasingly interested in the information resources available to private industry, particularly those with defense and space orientation. Those Committees that have taken an interest in the subject have felt that the new Defense Documentation Center renders an exceedingly significant service, one which could, no doubt, be improved even more if more resources were devoted to it. While there is a limit to the amount that a small number of people and a limited number of dollars can do in solving the over-all problem of information flow, there is also a question of diminishing returns; how much can be put into information services and still reap benefits? The United States Government is now spending approximately one hundred million dollars a year for scientific and engineering information services.[2] This represents a considerable sum, and it does not include indirectly-performed information services which are a normal part of research and development contracts.

The Defense Documentation Center faces a tremendous

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[2] United States Congress, House of Representatives, Select Committee on Government Research, Documentation and Dissemination of Research and Development Results, Report (Washington: Government Printing Office, 1964), Appendix C-2.

problem of capturing information which never enters into the mainstream. It does not receive information from any of the more than three hundred thousand subcontractors involved in defense and space efforts, and it receives only one out of every five Department of Defense-generated reports.[3] If the Defense Documentation Center has problems now, and if users have problems getting the information available, the significant fact is the mass of information that will become increasingly more unavailable. And, perhaps it should never become available! The point of diminishing returns may have been reached long ago, and it would not really be doing a service if 90 or 95 per cent of the available information was collected and stored.

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[3] *Ibid.*, p. 28.

# CHAPTER XI

## THE RESEARCH AND DEVELOPMENT INPUT TO DEFENSE POLICY

The problems of selecting strategies and choosing weapon systems today are quite unlike anything that existed before the Second World War. Before that time, military technology changed rather slowly in relation to the average length of military or political careers. Both soldiers and statesmen could learn most of what they needed to know about military power and the relationship of weapons systems and forces to national defense from their own direct experience and by reading history books. But something new has been happening in the past twenty years. In the words of Alain C. Enthoven, Deputy Assistant Secretary of Defense (Systems Analysis):

> Science and technology have gone through a "take-off" and they are now in a period of rapid, accelerating, and apparently self-sustaining growth. Nuclear weapons, nuclear power, computers, large-scale rockets, and space flights are but the most spectacular examples of a revolution which has been led by both military men and civilian scientists. Before World War II, we did not plan on technological change; we merely adjusted to it. Now we are planning on it. We are debating, whether inventions can be scheduled, and we have weapons systems that are being called obsolescent while still in production.[1]

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But the problem is complicated, in the face of the expanding number of systems that could be bought, by being unable to escape from the necessity for choice arising out of the scarcity of available resources. The United States today has only a limited amount of goods and services available at any one time, and the gross national product, though large, is limited. There is also only a finite number of manhours available for all forms of productive activity. An attempt to develop and procure a dozen or more distinctly different strategic nuclear delivery systems would doubtless result in squandering the resources that are available and not getting a good system in any of them. Therefore, a choice has to be made.

The military worth of the proposed system is not the only factor, as the cost also has to be considered. In the Defense Department's view, "military effectiveness and cost are simply two sides of the same coin" and must be considered jointly in the decision-making process. Comptroller Charles J. Hitch writes:

> We do not use systems analysis or cost/effectiveness studies as a substitute for sound and experienced military judgment, but rather as a method to get before the decision-maker the relevant data, organized in a way most useful to him. There are and there should be many other inputs to the decision-maker, particularly in those areas which are not susceptible in whole or in part to quantitative analysis.[2]

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[2]Wesley W. Posvar, et al. (eds.), American Defense Policy (Baltimore: The Johns Hopkins Press, 1965), p. 213.

How these imputs are coordinated by the Defense Department and the way they are fed to the decision-makers is the subject of this chapter. Policy guidance is a two-way affair. Consultation can be extended to DDR&E, policies can be coordinated with other government agencies, and policy recommendations can be forwarded up the line. Each avenue will be discussed.

## I. CONSULTATION TO DEFENSE RESEARCH AND ENGINEERING

### The Defense Science Board

This Board was established in 1956, following the recommendations made by the Hoover Commission. The Commission felt that the Defense Department should avail itself of the best technical brains in the Nation, while, at the same time, give the scientific community a direct channel into the Defense establishment. The purpose of the Board is to advise the Secretary of Defense through DDR&E on scientific and technical matters of interest to the DOD. Through its membership of distinguished men representing industry, government, and the academic world, the Defense Science Board serves as a connecting link between DDR&E and the scientific and technical community of the United States.

The Board is composed of twenty-eight members, with one full-time member, a DDR&E representative, who is

How these inputs are coordinated by the Defense Department and the way they are fed to the decision-makers is the subject of this chapter. Policy guidance is a two-way affair. Consultation can be extended to DDR&E, policies can be coordinated with other government agencies, and policy recommendations can be forwarded up the line. Each avenue will be discussed.

## I. CONSULTATION TO DEFENSE RESEARCH AND ENGINEERING

The Defense Science Board

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The Board is composed of twenty-eight members, with one full-time member, a DDR&E representative, who is

Executive Secretary to the Board. The eight ex officio members are comprised of the following:

1. Chairman, General Advisory Committee of the AEC;
2. Chairman, Army Scientific Advisory Board;
3. Chairman, Navy Research Advisory Board;
4. Chairman, Air Force Scientific Advisory Board;
5. President, National Academy of Sciences;
6. Director, National Science Foundation;
7. Director, National Bureau of Standards; and
8. Deputy Administrator of NASA.

Twenty other members are selected on the basis of their eminence in the field of research and development, including management and long-range planning, as necessary to represent the interests of the offices of DDR&E. Presently, the composition of the Board is loaded in favor of aeronautics, astronautics, nuclear technology, and physics, although an attempt is supposedly being made to broaden the Board's representation. Appointments to the Board, usually of three or four years' duration, are made by the Secretary of Defense, upon the recommendation of the DDR&E, and the concurrence of the Chairman of the Defense Science Board.

Typically, the entire Science Board meets three times each year, with executive committee meetings every two months. In the past, Board reports made to Secretary McNamara have not been accepted uncritically. It appears from the records that the more specific a study dealing with a weapons system is, the less impact it has. It is in the policy and planning guidance areas that the Board has its

greatest effect. When the DDR&E and his Deputies meet with the Board and executive committee, also often present are the Assistant Secretaries and General and Flag Officers responsible for the research and development programs in the Military Departments as well as a representative from the Joint Chiefs of Staff. These meetings provide firsthand face-to-face exchanges, to quicken and make more intimate the flow of opinions between the Government officials and their select advisers from the American scientific community.

## II. INTER-AGENCY COORDINATION

The Department of Defense has maintained effective working relationships with the other two agencies who participate in the defense research and development programs, the AEC and NASA, through two coordinating bodies, the Military Liaison Committee and the Aeronautics and Astronautics Coordinating Board.[3]

### Military Liaison Committee

With respect to the AEC, the Military Liaison Committee has the statutory duty to coordinate all mutual DOD-AEC activities, including research and development. As a

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[3]United States Congress, House of Representatives, Select Committee on Government Research, Federal Research and Development Programs, Part 1, Hearings (Washington: Government Printing Office, 1963), p. 174.

practical matter, since DDR&E is responsible for all Defense research and development, there is a direct and close coordination of these activities between that office and all divisions of the AEC, including the Commission itself. Direct correspondence is passed through the Chairman of the Military Liaison Committee, so that he is kept fully advised of transactions.

Aeronautics and Astronautics Coordinating Board

This Board was created jointly by NASA and the DOD in September, 1960. The co-chairmen of the Board are the Associate Directors of NASA and the DDR&E, representing the Secretary of Defense. The Board has eleven members, six of whom are chairmen of the six subsidiary panels which report to the Board, two of whom are the co-chairmen, and the balance of whom are members-at-large so as to provide representation from all interested parties within the two agencies. The six panels cover the principal areas of mutual concern to NASA and the DOD, which are grouped as follows:

1. Manned space flight;
2. Unmanned spacecraft;
3. Launch vehicles;
4. Space flight ground environment;
5. Supporting space research and technology; and
6. Aeronautics.

The panels have served not merely as committees, but as action groups to develop, coordinate, and implement plans and programs as jointly agreed and, in general, the personnel

on the panels have in their capacity as within their agency the power to carry out some of these decisions.[4]

To insure complete understanding between the two agencies, the policy has been adopted that major decisions involving both agencies will be the subject of basic agreements ratified in writing, at the appropriate level.

## III. DEFENSE RESEARCH AND ENGINEERING'S INPUT

### Policy Recommendations

The DDR&E is the President's link with the Defense research and development program in various ways. Of course, the Secretary of Defense is the first in the organizational chain to receive recommendations and formulate Department policy. But the DDR&E himself is also a member of the President's Science Advisory Committee (PSAC) and also the Directorate's position is one of the statutory members of the Federal Council for Science and Technology (FCST).

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## III. DEFENSE RESEARCH AND ENGINEERING'S ROLE

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the Presidency. They are not across-the-board, general purpose counselors, but rather they are experts in one particular area. In giving the President professional advice on scientific and technical questions, their role is akin to that of the Council of Economic Advisors in its specialized field.

FCST consists of the chief scientific officers of the eight Federal agencies most heavily involved in scientific activities. It is concerned primarily with resolving problems of a multi-agency nature and with coordinating the work among the agencies. FCST leans heavily on the scientific advice of PSAC and the National Academy of Science. Through various committees and the Staff of the Office of Science and Technology, FCST examines areas of primary national interests where a concentrated effort and a government-wide approach is deemed essential, either because of the magnitude of the activity or because of the multiplicity of the agencies involved. Whole scientific fields are reviewed with respect to scientific expectations and national goals, as well as gaps and overlaps.

Dr. Jerome B. Wiesner, who as former Special Assistant to the President for Science and Technology also held the positions of Chairman of both PSAC and FCST along with being the Director of the Office of Science and Technology, perhaps emphasizes the impact FCST has on national defense

when he commented that the Federal Council for Science and Technology is ". . . essentially a sub-Cabinet for Science, whose members have both a political or policy position and a technical position."[5]

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[5]Dr. Ralph Sanders, "The Autumn of Power: The Scientist in the Political Establishment," (Washington, D. C.: Industrial College of the Armed Forces, 1965), p. 9.

## CHAPTER XII

## SUMMARY AND CONCLUSIONS

In the preceding pages, an attempt has been made to analyze the organizations and activities of research and development effort for national defense. Policy, plans, programs, speculation, implementation, and arguments sweep the spectrum from beefing-up efforts to cutting costs. There is a tendency to look back, count the milestones of real or alleged progress, and pause to celebrate. But, in reality, more concentration is found on the little pockets of offices all through the research and development organization and in field tests all over the world where new goals of improved defense strength are just being shaped. These goals range from point sharpening refinements of existing routines through the brainstorming of new ideas to major weapon systems programs.

### I. SUMMARY

In broad generalities, it can be said that the Defense research and development effort, as organized and energized by one Dr. Harold Brown, is just beginning to become effective. In simplest terms, it all means, on the larger scale, a group of dedicated people have learned how to work well together, generally within the McNamara-instilled

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I. SUMMARY

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framework. The McNamara reign in the Pentagon has been depicted as "forced feeding of a diet of management." Opposition to the diet has gradually subsided and now many Department of Defense personnel, both military and civilians, have become addicted and are "hooked" for life on the precepts of good management.[1]

Nowhere is this addiction better indicated than in DDR&E. After an extended period, in which DDR&E exercised considerable control over the research and development functions of the Services, Dr. Brown is reportedly returning the reins back to the Military Departments. He is doing more toward building up the stature of the three Assistant Secretaries of research and development than any of his predecessors.

Of course, there are critics, such as Hanson Baldwin, who maintains that there has been a "definite reduction . . . in the evolution and production of new weapons . . . and more development contracts have probably been canceled than have new ones been initiated."[2] His criticism could be interpreted as saying that not enough money is being wasted. He apparently feels that there should be considerably more

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[1]"Defense Research and Engineering," Armed Forces Management, XI (November, 1964), 68.

[2]Hanson W. Baldwin, "Slow-Down in the Pentagon," Foreign Affairs, XLIII (January, 1965), p. 263.

decision-making within the Services and less supervision from the Office of the Secretary of Defense. This feeling is to some extent oriented toward the old system of each Service writing its own ticket. In the interest of eliminating--not healthy service competition--but duplicatory and unnecessary Service rivalry, Baldwin recommends the following:

1. Abandon attempts, keyed primarily to costs, not effectiveness, to force Service weapons systems into "all purpose" molds. "Commonality" develops naturally from actual technological accomplishments, not from "project definition phases" or paper plans.

2. Return, insofar as possible, to competition in hardware rather than competition on paper. The end product is almost certain to be better, and ultimately may cost less.

3. Sponsorship, within a Service, or by two or more Services, of competitive research and development projects, all having a common goal, but each following different technological paths to that goal.

4. Definite selection by the Defense Department at the earliest possible stage of the best project; cancellation of the others.[3]

A look at the above recommendations would indicate that the "project definition phases" criticized in point number one is designed to accomplish the recommendation of point number four. Points number two and three are countered by DDR&E recommendations that the Military Departments

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[3] Ibid., pp. 279-280.

should be encouraged to increase the flexibility of programming documentation in advanced developments by directing it less toward definitive single-system solutions and more toward the use of multiple approaches.

The problem of national defense has become extremely complicated technically, and the scientific method is a powerful intellectual tool to supplement conventional decision-making norms. This method combines logic and empirical evidence with deductive and inductive reasoning in an explicit and verifiable presentation of the hypothesis and its acceptance or rejection. It aims at objectivity by minimizing the influence of personalities or vested interests. While the theoretical tests of the conclusions are based on logic, experiments, and history, unfortunately, fully-realistic proofs come only in the exchange of battle. While the methods are, by purpose, scientific, their application synthesizes many subjective valuations and estimates. Personal assessments guide the collection, processing and interpretation of cost and effectiveness data, and it is difficult for the participants to exclude special preferences for this or that course of action. Except where there is a simple, one-dimensional objective under scrutiny, judgment exercises a critical role in designing the analyses, choosing the alternatives to be compared, and selecting the criterion.

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In instances where the "data" per se involves the exercise of judgment, or in the field of interpersonal or international relationships where complex patterns of behavior are the rule, such techniques are not infallible aids in framing reliable value premises. The personnel participating in these investigations must constantly be aware of the assumptions made in the model, query the reliability and range of error of the data, and recognize that many pertinent aspects to the methods will never achieve mathematical expression. It must be realized that the scientific method, then, is simply one of several means to an end.

Francis X. Kane, writing in Fortune, criticized Defense's attempt to search for perfection on paper before any operation begins. He says:

> The closer the planner approaches perfection, the more certain he will be that he possesses the edge on the enemy. If certainty is unattainable, it is also unnecessary. This observation applies especially to current requirements that the results of the research and development process be certified before the process is begun. As military affairs go now, schedules, results, and costs must be forecast before a new project is approved; quantitative measurements are the principal criteria of progress. Clearly by any standard and by the primary practical standards this goal is unattainable. In practice, the need for forecasting with certainty is a barrier against constructive action.[4]

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If one is to believe Mr. Enthoven when he talks about the limitations on money and manpower along with the increase in number and cost of potential weapons systems, Mr. Kane's argument loses its credibility.

Of particular concern in the defense posture is the level of effort in advanced developments. Security effectiveness is largely determined by the state of scientific and technological advancements. New systems must be aggressively pursued, based on both the assessment of the threat and the pace of technology. One of the most serious criticisms of present procedures is leveled against a "tight" research and development budget with emphasis primarily on operational improvements. Although improvements are needed on existing operational systems, an evaluation of the threat clearly shows that the need becomes even more crucial in the late 1960's and early 1970's, when new concepts and systems will be required. A "tight" approach does not permit the flexibility to explore potential concepts that might provide some of the solutions being sought. This is not to imply that money should be wasted on projects that are not needed; but when faced with problems in an area that is both crucial and extremely complex, new ideas and new programs cannot be strait-jacketed by either a lack of funds or a lack of encouragement to explore new avenues.

A corollary matter that is also pertinent is the

effect on initiative and morale in both the defense agencies and industry which have the responsibility for conceiving and developing new systems. Considering the challenges that face the United States, due to the advances in technology and the capability of the expected opponent, research and development personnel should be encouraged, not stifled, to generate new ideas and systems. By holding down the level of funds and delaying decisions to go ahead on development and production programs, initiative from which new concepts might be realized is discouraged.

Wails of remorse from pessimistic sources in defense industry appear quite unfounded, but frequent, in lieu of figures released by the Department of Defense concerning expenditures in the area of military research and development. The figures indicate that the research and development budget was expected to level off in the forthcoming years. Cries of anguish predicted the complete collapse of the defense market. DDR&E's reply to these protests are, "we are not in business to keep industry alive."[5] Made in terms of a simple statement of policy, DDR&E meant that the sole aim of the Defense Department is not to maintain a prosperous and thriving defense industry. Granted, this industry is a very

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vital part of the nation's defense effort. Eugene G. Fubini, Deputy Director of DDR&E, wrote that he or the members of the DOD cannot always know what is needed. He believed that it was up to industry to discover the needs that are present but not recognized.[6] But, in this era of rising costs and sophisticated technologies, a longer and harder look must be taken at programs and the companies developing them before obligating the millions of dollars it takes to vitalize a system.

Some facts concerning Department of Defense research and development expenditures over the past four years may indicate the state of the situation.

1. The last approved budget was the third highest since World War II.
2. There has been a 50 per cent increase in expenditures over the level prevailing during the four preceding years.
3. Over twenty-six billion dollars have been invested in the program, one billion dollars more than were spent during the entire eight previous years.
4. In 1964, seven cents of every dollar spent by the Federal Government went for this program.
5. More than two hundred major new projects have been undertaken since 1961, including some seventy-seven weapons programs each costing more than ten million dollars.[7] In 1964, as much was spent to explore the military aspects of space as was spent on the entire space program four years ago.

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6. More than $234,000,000 a year is being invested in basic research, 66 per cent more than was spent for the same purpose in 1960.

Expenditures do not, of course, tell the entire research and development story. Under the guidance of Dr. Brown, who ably practices what Secretary McNamara preaches, an attempt is being made by Defense to obtain a better product in terms of efficiency and quality. The methods used by the DOD have two positive values. They provide the decision-maker with a set of carefully-described alternatives which, nevertheless, do not preclude other courses of actions and which should be tested against other criteria to ascertain their effect on organizational goals. Decision-makers should not look for a single optimum solution, possible only in the abstract, but rather for guidelines of a preliminary but not necessarily definitive sort. Secondly, the methods challenge non-staff personnel to defend their own preconceptions. From this interaction of challenge and response, there emanates new alternatives, procedures and policies.[8]

Few will deny that full costing of weapons systems, the projection of five-year budgets, the prudent weighing of immediate and long-run benefits, and closer scrutiny of research and development proposals must bear fruit in a more

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[8]John J. Clark, "The Management of National Defense by Systems Analysis: An Evaluation," The Royal United Services Institution Journal, CIX (November, 1964), 305.

efficient and economical Defense establishment. By challenging the _status quo_ and forcing scrutinization of accepted practices, the review initiated and the consequent obligation to defend and challenge opposing viewpoints leads inexorably in the spirit of scientific inquiry to alternative methods of achieving the desired objectives. Goals have always been similar, but now methods of accomplishment are also becoming increasingly similar as Defense standardizes practices and procedures and practitioners become more management-oriented.

## II. CONCLUSIONS

Since the United States has departed from isolation to become involved in the world system of power rivalries, science and technology have reached a position of unprecedented importance in the maintenance of national defense. An understanding of the ways in which research and development are continuously changing the conditions of social, industrial, political, and military affairs; and an extreme alertness to their potentialities for future change are essential in the military forces. In fact, one of the gravest defects which could exist in the defense system of any major power in this period would be a feeling of contentment regarding national armaments and the national economy, in general. An attitude of satisfaction with

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things as they are would be apt to result in inaction, permitting the tide of technology to rush past, leaving the Nation's defense obsolete and insecure.

Another facet of this conclusion is that, in reality, there is no particular national security program that is needed in an absolute sense. The question is, how much is needed for one defense program more than is needed for the other purposes? To get the most out of the Nation's resources, fewer billions may have to be spent on some activities which are worth less to the Nation than they cost, to allow more for programs that yield greater values than the costs incurred. Although military worth may be defined as capabilities to inflict specified damage upon an enemy under described technological conditions, a methodology has not been devised to permit military worth to be expressed in any common denominator which makes it directly comparable to costs. This deficiency sets up a formidable obstacle to pinpointing the optimal solution, compared to the market place, wherein money serves as the common denominator of worth and costs.[9]

The United States finds itself in a situation of unprecedented technological challenge. The resources which

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are available to do the job are far less, relative to the size of the job, than what has been available in the past. Unprecedented technological challenge does not necessarily mean that better ideas will be coming along every day or that more revolutionary changes will come even faster. As a general rule, the developments that will become available, if successful, would add only marginally to the over-all strength. There have been and are exceptions--developments which can add a new and unique dimension to a capability, such as the hydrogen bomb, the ballistic missile, and the nuclear submarine. These developments are factors of a thousand improvement, and are harder to come by. Dr. Brown maintains that a factor of ten improvement in today's innovations is worth big research and development investment.[10]

When the potential pay-off is extremely great, correspondingly-greater costs and risks are justified, but developments which meet this test are rare. The typical development promises, if successful, to achieve a capability that can also be achieved in other ways, usually the more extensive or imaginative use of existing weapons. In such cases, the urgency is not so great.

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[10] United States Congress, House of Representatives, Committee on Appropriations, Department of Defense Appropriations Bill, 1966 (Washington: Government Printing Office, June 17, 1965), pp. 79-80.

However, the scientists are not giving up. Dr. James R. Killian, former Special Assistant to the President for Science and Technology expresses his view with:

> I am troubled when I hear statements about our having reached some kind of plateau in our inventions and development of new weapons. . . . The cold war is not over; our military technological innovations must advance . . . maintaining a margin of superiority is not partisan and can be accomplished only by an advancing military technology. Our science and technology must be so good and so far out on the frontier that it is we who have the capability to anticipate advances and do things unimagined by others.[11]

For any nation, research and development constitutes an essential element of progress and, in particular, of national defense and economic strength. The various systems on which the United States national defense rests are the products not of circumstance but of the most astute research and development planning that man and machine can provide. The planning anticipates the hardware for as far as a score of years into the future. Beyond the plans lie the processes that carry the new idea from the drawing board to the active inventory. As the formula grows more complex, the function of the policy-makers' decisions becomes ever greater in compounding the elixir for technological supremacy. These decisions are critically dependent upon able leadership and staffing within the governmental departments and agencies.

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[11]James R. Killian, "The Innovation Industry in Transition," Technology Review, LXVI (June, 1964), 40.

It is concluded that the basic concept of organizing research and development activities around the missions of departments and agencies is sound and should not be significantly altered. The benefits of vitality, flexibility, and control offered by decentralized mission orientation are significant and should be preserved. With few exceptions, intra-agency research and development policy formulation is the strongest aspect of policy formulation in the Executive branch. The specters of overlap, gaps, conflicts, and duplication among agency programs can best be met through adequate top-level coordination of agency programs to meet total national needs. Inter-agency coordination considers key policy questions, such as the effective development and utilization of research resources, the proper roles for research-performing institutions, the impact of research and development on particular economic and regional sectors, and the maintenance of an adequate research and development base to support economic and national defense policy.

Today, the research and development program is one of the most critical elements of the Nation's strength. A summary of the basis for this program is as follows:

1. There is a need to strive for substantial superiority in a technological war which has no current prospect of ending.
2. There are direct and important relationships between threat, strategy, and national defense on the one hand--and research and development on the other.

3. During the past ten years, the scope of research and development has expanded dramatically in response to the requirements of national strategy.
4. Research and development has successfully met its principal objective by providing superior weapons systems in an attempt to assure national survival.
5. Research and development is proceeding with a broad range of development programs and technology in an effort to maintain military superiority.

Technological superiority alone does not guarantee national survival, but it is an essential part of national security and must be maintained. Choosing the technologies which are to be supported, the development programs which are to be carried out, and the way they are to be managed is, therefore, one of the Nation's most vital tasks. It is necessary that the process of selection between a myriad of possibilities be made more carefully when "imminent danger" is not present; to do otherwise would involve an absurd proliferation of marginally useful items. Making the choice is a most difficult job, but one which must be done by defense research and development.

The Federal research and development effort has the capability to make quantum advances if pursued aggressively and purposefully. Such effort will pay off by continuing to produce a deterrent capability in future years to insure the security of the United States. But these efforts cannot succeed if impeded by too rigid demands that operational

requirements be specifically defined before allowing new technical developments to be undertaken. Such restrictions stifle creativity, the evolution of new ideas, and the incentive to explore new horizons of science and technology. The pace of advancement must reflect both a realistic assessment of the threat and the advances in technology. An orientation to reflect this approach, coupled with the necessary decisions to implement it, is required to reduce the possibility of increasing vulnerability during the next decade.

It is not recommended that funds be expended on worthless items; but if an error is made, it should be on the side of too much, rather than too little. In other words, the approach should be to pursue new concepts and ideas so they will supply the best operational alternatives to the national defense decision-makers, if the requirement ever arises.

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